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ВСЕСОЮЗНЫЙ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ИНСТИТУТ
МОРСКОГО РЫБНОГО ХОЗЯЙСТВА И ОКЕАНОГРАФИИ (ВНИРО)

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Под редакцией
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Т. И. Макаровой

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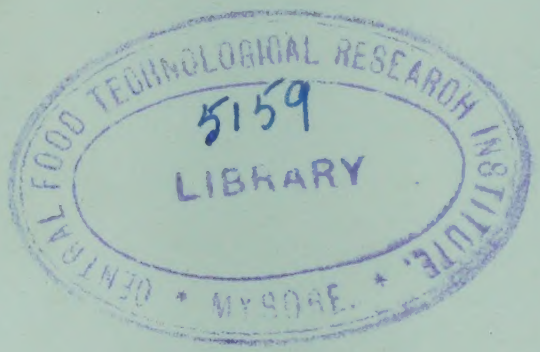

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USE OF NATURAL COLD IN THE AIR CONDITIONING OF FISH-PROCESSING PLANTS

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Candidate of Technical Science

Among the measures which contribute to the improvement of production standards and of living conditions, the use of air conditioning in industry and in domestic premises, occupies a prominent place.

As is well known, air conditioning has the purpose of establishing and maintaining in closed premises a fixed temperature, humidity, rate of circulation of air, and pressure and purity of air, irrespective of the corresponding parameters of the outside air.

Depending on the requirements, air conditioning systems designed to have an all-year-round effect are distinguished from systems for only seasonal effect. Apart from this, air conditioning can be absolute, i.e., maintaining simultaneously the required temperature level, relative humidity, air circulation rate, pressure and purity or partial, i.e., when one of the above-mentioned values is subject to adjustment.

Such air conditioning can be designed according to three distinct systems, viz., central, local, or a combination of both.

Central systems are usually installed to cover large individual premises, for example, theaters, concert halls, and industrial plants, or to cover a whole group of smaller premises, used for similar purposes. The capacity of this type of system varies from 10 to 40 thousand m^3 hour.

Local systems with conditioners of a capacity of 0.5 to 10 thousand m^3/hour are used to serve small premises (such as laboratories, offices), or a whole group of such premises.

Combined systems, which have become popular in recent years, and which are applied, in particular, in tall buildings [1] consist of a central conditioning unit, producing air of a given absolute humidity, combined with a group of local conditioning units supplying air to individual premises.

In all types of existing air conditioning units for the cooling of air, artificial cold is applied, i.e., mechanical refrigeration installations. The calculation formula of such conditioning units has been fully worked out and these conditioning units are successfully employed in various industrial enterprises, including places where food and other consumer goods are manufactured.

However, in fish-processing enterprises, air conditioning has not yet been applied although the need for it is evident. The application of air conditioning in

fish-processing plants (fish canning and preserving-plants) would make it possible to maintain at any time of the year a temperature level in the range of 8° to 10°, with a relative air humidity of 75% to 80%. Under these conditions the development of microflora on fish could be arrested, and the hygienic conditions of the plant improved.

Sufficient information is given in the relevant literature regarding the influence of temperature on the development of microflora on fish.

Chistyakov and Bocharova /17/, in their study of the influence of low temperatures on the development of fungi in food-producing enterprises, found that by reducing the temperature from 20° to 10°, the growth of Penicillium glaucum is retarded by two days, by decreasing it to 5°, growth is retarded by 6 days, to 2°, by 7 days, and to 0°, by 13 days.

Ignatovich and Tarasova /5/ showed that certain bacteria which cause fish decay (Bac. cloacal, Bac. Superficiabes, Bac. coli), have each a varying rate of development, governed by the temperature of their environment; i.e., at 10°, two times slower, and at 5°, four times slower than at a temperature of 18°.

Korobochkin /8/ has noted that even a slight rise in the temperature of a plant from 2° to 3° results in an increased rate of growth of microflora on fish, thereby causing a deterioration in the quality of the fish.

Gorovits-Vlasova /2/ has indicated that any rise in the temperature above 0° results in increased growth of microflora on fish. From the data indicated above, and from other available data dealing with this problem, it is recommended that fish be processed at a temperature not higher than 10°.

For air conditioning in fish-processing plants, it would be advantageous to utilize natural cold. Such installations, however, and the relevant methods of calculating such conditioning units have not yet been fully explored.

Such sources of natural cold as ice, artesian water, and also ground cold accumulated during the winter months could be utilized for air refrigeration.

In 1936 Gogolin /3/ experimented with an air conditioning installation utilizing ice as the cooling agent. The cooling capacity represented 15,000 kcal/hour while the ice consumption was about two tons per day. For a cistern of a 1 m^3 volume at a rate of flow of 2.13 m^3/m^2 hour, the coefficient of heat transfer comprised 3,500 to 4,000 kcal/m^2 hour degree.

The advantage of the ice-cooling system is in the low cost of its equipment and installation, and also in the low operating cost. Disadvantages of this system are the necessity of crushing the ice and the constant loading of the cistern in addition to certain difficulties which are encountered in regulating the air temperature.

In our opinion it would be advantageous to utilize the natural cold accumulated in the ground during the winter season for air conditioning fish-processing plants.

In areas of perennial frost it is comparatively simple to use the accumulated ground cold for air conditioning in plants. In other areas, however, where the air temperature drops to 20°–30° below zero in winter, and it rises to 20°–30° above zero in summer, it would be necessary to employ special equipment for the accumulation of large reserves of ground cold during the winter.

Following are certain calculations connected with the process of ground

cold accumulation, and the results of experiments carried out on freezing of the ground .

Calorific Calculations Pertaining to the Accumulation of Natural Cold in the Ground during Winter

The amount of accumulated ground cold, and the rate of formation of massive ice blocks through the process of natural cold depends upon many factors:

a) The physicomechanical properties of the ground, its density, heat conductivity, heat capacity, water content, the presence of various chemical substances, etc.

b) Temperature of the cold carrier and of the ground itself.

c) Circulation velocity of the cold carrier and its properties.

d) Construction of equipment for ground cold accumulation.

The type and construction of the equipment necessary for the accumulation of natural cold were described in detail by the author in 1952, in the Transactions of VNIRO/7/. Therefore, only thermo-technical problems will be elaborated upon in this article.

For ground freezing it is suggested that a concentrated solution of calcium chloride be employed in the capacity of cold carrier, the cold solution being fed through a feeding pipe into the lower part of a cold well located in the ground. Losing a certain amount of cold to the lower strata of the ground, the rising defrosted solution is conveyed into the cooling tower, where it is recooled by contact with the lower temperature of the external air (Figure 1).

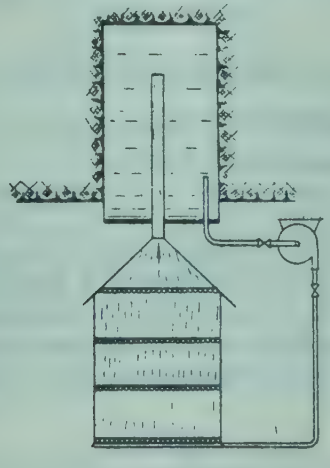

Figure 1. Installation plan for the accumulation of cold in the ground

The frozen ground encircling the well will have the form of a truncated cone. The dimensions and velocity of formation of the massive ice blocks will depend upon a whole range of functional relationships and independent variables. The determination of the form, size, and rate of formation of the massive ice blocks can only be approximate, taking into account that the ground which is being subjected to freezing possesses certain constant mean properties. For practical purposes, when ground freezing in shallow depths, the calculations could be based on the assumption that the frozen ring encircling the well has a regular shape. Thus, approximate

methods of calculation have to be used, which may be regarded as sufficiently accurate for all practical purposes, permitting the determination of a fairly narrow range within which lies the exact solution.

It is necessary to determine the following factors for the purpose of calculation:

1) Amount of heat extracted from the ground for the formation of the frozen mass.

2) Amount of cold transmitted to the ground through the walls of the cold well.

3) Inflow of heat towards the frozen ground mass(in the absence of ground currents).

4) The dispersion of the temperature field in the ground in the course of freezing.

Amount of Heat Extracted from the Ground for the Formation of Ice Blocks

It is known that all types of heat exchange inside a single body, or between two bodies (thermal conductivity, convection and radiation) can occur only when there is a difference in the temperatures.

The basic proposition of the theory of thermal conductivity is the Fourier Law, according to which the quantity of heat which penetrates the elements of the isothermic surface inside a body is proportional to its temperature gradient.

The Fourier Law can be expressed by the following equation:

$$dQ = -\lambda \frac{\partial t}{\partial n} df d\tau, \qquad (1)$$

where: λ = the coefficient of thermal conductivity in kcal/m hour degree

$\frac{\partial t}{\partial n}$ = temperature gradient in degree/m;

df = elementary area in m^2;

$d\tau$ = time element in hours.

A double integration of the equation (1), with respect to area and time, is possible if the temperature is represented as a function of the coordinates and the time. In order to obtain such a functional relationship, a differential equation of heat transfer is worked out. If there is no internal source of heat, and there are no temperature variations on one coordinate only, this equation has the following form in cylindrical coordinates:

$$\frac{\partial t}{\partial \tau} = a \left(\frac{\partial^2 t}{\partial r^2} + \frac{1}{r} \frac{\partial t}{\partial r} \right). \qquad (2)$$

where r = the radius of the well accepted in the coordinates;

$\frac{\partial t}{\partial \tau}$ = rate of temperature change with time in degree hour;

a = coefficient of thermal conductivity in m^2/hour.

Most of the practical problems of heat transfer can actually be reduced to the instance of an established condition when the temperature at any given point of the body does not depend upon time, i.e.,

equation (2) is reduced to

$$\frac{d^2t}{dr^2} + \frac{1}{r}\frac{dt}{dr} = 0. \qquad (3)$$

Equation (3) can be used for calculating the rate of heat transfer through a cylindrical wall.

The integral of equation (3) will show two derivative constants determined by the given boundary conditions.

The most widely used boundary conditions are: 1) given temperature range on the wall surface (first type), and 2) given temperature range of the immediate environment of the cylindrical wall (third type); in such a case Newton's Law on heat exchange between the wall and the environment is accepted.

$$dQ = \alpha (t_f - t_s)\, df d\tau, \qquad (4)$$

where: t_f = temperature of wall surface in degrees;

t_s = temperature of immediate environment in degrees;

df, d_τ = corresponding elements of area and time;

α = coefficient of heat emission in kcal/m^2 hour degree.

Applying equations (1, 2)' for the calculation of heat transfer through the wall, it is possible to determine the amount of heat that has to be extracted from the ground during the process of freezing, or from the water contained in it.

The total quantity of heat extracted from the ground can be determined according to the following formula:

$$Q = W_0 \gamma c (t_2 - t_1) \text{ kcal} \qquad (5)$$

where W_o = total volume of ground or water to be frozen;

γ = specific gravity of the ground, or the water;

c = specific heat of the ground, or the water;

t_1 = initial temperature of the ground, or the water;

t_2 = final temperature of the ground or the water.

Since the ground to be frozen has a certain water content, the heat extracted from the ground in the process of forming the frozen mass is apportioned according to the following phases:

1) the cooling of the water contained in the ground from its initial temperature to 0°,

$$q_1 = W_w \gamma_w c_w (t_1 - t_2),$$

where: W_w = volume of water contained in the ground;

γ_w = specific gravity of water;

c_w = specific heat of water;

t_1 = initial temperature of the ground;

t_2 = final temperature of the water, in this case 0°;

2) freezing of the water, cooled to 0°

$$q_2 = W_w \gamma_w R,$$

where R = latent heat of ice formation, equal to 79-80 kcal/kg of water;

3) cooling of the ice from 0° to the given temperature of the frozen ground:

$$q_3 = W_w \gamma_w c_{ice} (t_2 - t_0),$$

where c_{ice} = specific heat of ice and
t_2 = final temperature of the ice cooling process;

4) the cooling of the solid components of the ground from the initial to the final temperature:

$$q_4 = W_n \gamma_n c_n (t_1 - t_2),$$

where W_n = volume of ground layers without water, i.e., ground "skeleton";
γ_n = specific gravity of ground layers;
c_n = specific heat of ground layers.

The total quantity of heat extracted from the ground and from the water contained in it will equal:

$$Q = q_1 + q_2 + q_3 + q_4,$$

or

$$Q = W_w \gamma_w c_w (t_1 - t_0) + W_w \gamma_w R + W_w \gamma_w c_{ice} (t_2 - t_0) + W_n \gamma_n c_n (t_1 - t_2) \text{ kcal.}$$

In converting this expression, and simultaneously substituting the volume of ground layers W_n by the difference between the total volume of the ground and the volume of the water, which is equal to $W_o - W_w$, we obtain:

$$Q = (W_0 - W_w) \gamma_n c_n (t_1 - t_2) + W_w \gamma_w (c_w t_1 + R + c_{ice} t_2) \text{ kcal.}$$

The volume of water W_w contained in the ground is $W_w = W_o m$, where m equals the ground porosity expressed in percent.

Substituting W_w in the given formula by $W_o m$, we obtain an expression which determines the quantity of heat extracted from the ground and from the water during the process of freezing:

$$Q = (W_0 - W_0 m) \gamma_n c_n (t_1 - t_2) + W_0 m \gamma_w (c_w t_1 + R + c_{ice} t_2) \text{ kcal.} \qquad (6)$$

There are practically no limits to the area of the spread of the cold in the ground outside the range of the frozen mass. However, the temperature in this ground will rise from the final to the initial with the increase of the distance from the cold well.

A certain amount of cold will be lost on the cooling of ground areas adjacent to the frozen mass. In effect this cold loss can account for 20 % of the amount of cold actually required for the process of ground freezing.

Thus the amount of heat extracted from the ground will be:

$$Q = 1.2 \, (W_0 - W_0 m) \gamma_n c_n (t_1 - t_2) + W_0 m \gamma_w (c_w t_1 + R + c_{ice} t_2). \qquad (7)$$

The Amount of Cold Transmitted to the Ground through the Walls of the Well

The heat which has to be extracted from the ground is transferred through the walls of the well, thereby effecting a transfer of heat between the ground and the brine circulating the well.

It has been experimentally established that when the temperature of the brine reaches minus 20-25° , an average of 200-250 kcal/hour /4 - 12/ can be transferred through 1 m^2 of the lateral surface of the well.

Thus, the amount of cold which can be transmitted through the whole surface of the well during a one-hour period is:

$$Q_1 = SK,$$

where S = the lateral surface of the well in m^2 and
K = the coefficient of cold transmission through 1 m^2 of the lateral surface of the well.

The lateral surface of the well is equal to:

$$S = \pi DH,$$

where D = the outer diameter of the well in m, and
H = the depth of the well in m.

Time necessary for the extraction of required quantity of heat from the total volume W_o will be equal to:

$$\tau = \frac{Q}{Q_1} = \frac{1.2[W_0 - W_0 m)\gamma_n c_n (t_1 - t_2) + W_0 m \gamma_w (c_w t_1 + R + c_{ice} t_2)]}{\pi DHK} \quad (8)$$

Flow of Heat into the Frozen Ground Mass

As a result of the heat flowing into the frozen ground, which is caused by the temperature difference between the frozen and the unfrozen ground, a significant quantity of cold escapes.

In meteorological work /10/ heat current in soil is usually calculated on the basis of the equation:

$$Q = -ac_v \frac{T_2(t, x_2) - T_1(t, x_1)}{x_2 - x_1}, \quad (9)$$

where a = the coefficient of temperature conductivity;
c_v = thermal capacity (per volume);
T_1 and T_2 = temperature measured at respective depths of soil, and
t = surface temperature of the wall of the well.

11 The calculation according to equation (9) can introduce significant errors owing to a substitution at a certain point of a derivative by the finite difference, and also as a result of inaccuracies occurring in temperature measurements and in the determination of the ground levels at which the temperatures are taken. The relative error in the determination of the heat current $\frac{dQ}{Q}$ is expressed by the following equation:

$$\frac{dQ}{Q} = 2\frac{dT}{T_2 - T_1} + 2\frac{dx}{x_2 - x_1} + E,$$

where dT = error occurring in the course of temperature measurements;
dx = error occurring in determining ground levels at which temperatures are measured.
E = error occuring by substituting the finite difference for the derivative of the function. It is difficult to determine the coefficient E.

It is possible to obtain another formula to permit the calculation of the heat current with great accuracy by applying the equation of heat conductivity.

Inasmuch as the heat conductivity coefficient in soil may be considered constant in relation to depth, the heat conductivity equation will acquire the form:

$$\frac{\partial T}{\partial t} = a\frac{\partial^2 T}{\partial x^2}. \tag{10}$$

Therefore by the transformation of this equation it is possible to obtain a formula for the heat current at any time. For this purpose equation (10) is multiplied by (x - H), integrated from 0 to H, and transforming it further, we obtain:

$$P = \frac{ac}{H}[T(t,O) - T(t,H)] - \frac{c}{2H}\frac{dx}{dt}\int_0^H T(t,H)\,d(x-H)^2, \tag{11}$$

where P = heat current at time t, and
H = depth of well in m.

Approximate Calculation of the Range of Temperature Distribution in the Ground upon Freezing

In the course of freezing of the ground its temperatures will change in time and space, i.e., the heat conditions are not stationary.

The spreading of a nonstationary heat current across a flat wall of infinite thickness, the temperature can be determined according to the following equation:

$$T = \Theta + (T_0 - t)\,g(\eta), \tag{12}$$

where T = required ground temperature at a given distance – x meters – from the source (surface of the cold well) at T hours after commencement of the freezing process;
θ = the temperature difference between the frozen and the nonfrozen ground;
T_o = initial temperature of ground and water;
t = ground temperature at the surface of the cold well;
g = hourly rate of flow of heat towards the wall of the well in kcal/hour
η = coefficient of useful cold emission in percent.

$$g(\eta) = g\left(\frac{x}{\sqrt{4at}}\right) = \frac{2}{\sqrt{\pi}}\int_{n=0}^{\eta=\frac{x}{\sqrt{at}}} l^{-n^2}\,dn \text{ (Gaussian integral)}$$

where $a = \frac{\lambda}{c}$ coefficient of temperature conductivity in m^2/hour;
λ ground heat conductivity coefficient in kcal/m hour degree, and
c specific heat of the ground in kcal/m^3.

The heat conductivity formulas applying to a flat wall can also be applied to cylinders, if the correction factor, equal to

$$\varphi = \frac{\left(\frac{x}{r^2} + 1\right)}{2\left(\frac{x}{r^2} - 1\right)} \ln \frac{x}{r_2},$$

where r = inner diameter of cylinder in m and
r_2 = outer diameter of cylinder in m, is introduced.

Introducing the correction factor into formula (12), and performing the relevant mathematical transformations, we obtain:

$$T = \Theta + (T_0 - t)0.5\varphi \frac{\sqrt{m_s + q_s t}}{\lambda t}, \qquad (13)$$

where m_s = mean thermal capacity (per volume) and
q_s = quantity of cold per 1 m^3 of frozen ground in kcal/m^3 hour.

We determine the time τ required for reaching the temperature at distance x from the surface of the cold well;

$$\tau = \frac{m_s}{4\lambda\left(\frac{\varepsilon}{y'x}\right)^2 - q_s} \text{ hours} \qquad (14)$$

From this formula one can calculate the time required to reach the given temperature in the ground at any distance from the source of the cold.

Freezing of Ground under Laboratory Conditions

In the course of experiments on freezing and thawing of moist ground, carried out by us in order to use the accumulated natural cold for industrial purposes, the study of the problems connected with the changes which would take place in the physical and physicochemical properties of the ground was not undertaken, since a similar study had already been carried out on a broad basis by the Institute of Refrigeration of the AN SSSR*. In the works of the Institute [14, 15, 16] a theory on the equilibrium state of water frozen in ground (relation of weight of ice to weight of total water content in frozen ground) was elaborated, and it was proven that the iciness of the frozen ground was not completely due to the constant presence therein of a certain quantity of unfrozen water. In other words, only a part of the water present in the frozen ground exists in the ice phase. Without knowing the degree of iciness of the frozen ground it is impossible to determine the quantitative ratio of its components (solid mineral particles, ice, water and air) necessary for thermophysical calculations connected with the freezing and thawing of the ground. In the above-mentioned works [14, 15] it has been established that in the course of freezing and thawing the latent heat of the formation of ice is not fully liberated at the boundary of freezing and thawing. This basically new situation renders it necessary for us to formulate the thermophysical problems connected with the exploitation of accumulated natural cold, taking into account the liberation of the latent heat of ice formation into the whole mass of frozen ground.

The frozen ground is a complex intricate polyphase system in which water exists in different states: solid, liquid and gaseous. The processes occuring in the ground during freezing, when frozen, and during thawing are to a considerable extent governed by the equilibria of the separate phases of water. The movement and winter accumulation of moisture, the physicochemical processes at negative temperatures, and the peculiarities of the physical and physicomechanical properties of

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* [Academy of Sciences, USSR].

frozen ground are actively connected with the presence therein of unfrozen water, i.e., water in a liquid state.

The quantity of unfrozen water in frozen ground is determined by:

a) the nature of the ground: the specific surface area, mineralogical composition, exchange coefficient, and the character of the exchangeable cations;

b) the content and composition of water-soluble compounds, and

c) the external conditions - temperature and pressure.

In conformity with the principle of the equilibrium state of water contained in frozen ground, the phase composition of the water is in dynamic equilibrium with the external reactions /15/.

In the course of the freezing process (particularly in its initial stage, and in the region of the important phase transformations of water, an intensive ion migration takes place towards the freezing front which also exerts a substantial influence on the processes occurring in the ground during freezing and thawing.

In thermophysical calculations of frozen ground it is essential to determine the quantity of unfrozen water and ice present. Using the calorimetric method difficulties are encountered in determining the quantity of unfrozen water and ice present under field conditions, and it is therefore necessary to determine these quantities by means of calculation.

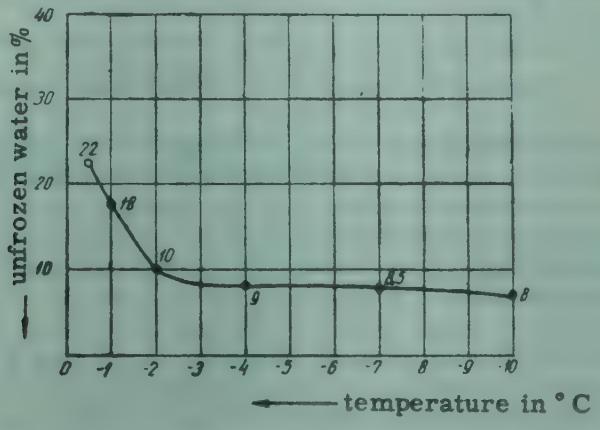

Figure 2. Amount of unfrozen water in the ground, depending on temperature.

Nersesova /16/ established experimentally that the quantity of unfrozen water present in the ground is governed by the degree of the negative temperature, and not by existing ground moisture. From this it can be deduced that the possibility exists of calculating the relative iciness (or coefficient of iciness) of the ground on the basis of given factors of ground moisture W and the experimental curve (Figure 2) which characterize the changes in the amount of unfrozen water. W_u present in the ground depending upon the temperature, by employing the following formula:

$$i_0 = 1 - \frac{W_u}{W} \qquad (15)$$

where W_u = quantity of unfrozen water in % of the weight of the dry ground and

W = total ground moisture in % of the weight of the dry ground.

For example, if the ground moisture W is 25%, and the ground temperature is minus 2°, the coefficient of iciness will be:

$$i_0 = 1 - \frac{10}{25} = 1 - 0.40 = 0.60.$$

Consequently, at the given temperature (minus 2°) the iciness of the ground comprises 60%. This coefficient should be taken into account in thermal calculations of frozen ground.

The equipment employed for experimental ground freezing consisted of a cubic wooden box holding 3 m^3 of earth, in the center of which was inserted a metal pipe 200 mm in diameter (Figure 3).

By means of centrifugal pump a solution of sodium chloride at a temperature of minus 15–20° was pumped through the pipe. The brine was cooled in an open evaporator in the coils of which Freon–12, fed from automatic refrigerating equipment AK–2FV–8/4, was vaporized.

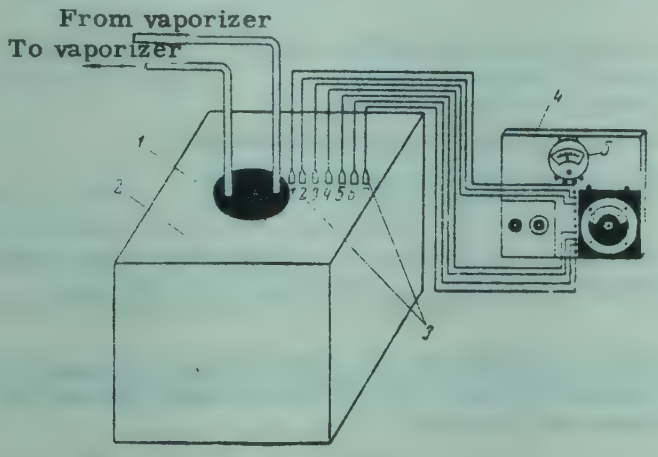

Figure 3. Experimental apparatus for freezing of the ground

1 - freezing column; 2--ground; 3--resistance thermometers; 4–thermic station; 5–galvanometer.

The equipment used for measuring the temperature in the ground during freezing consisted of a heat–measuring device with resistance thermometers which were placed in the ground at a depth of 0.8 m from the surface at increasing distances from the freezing column (pipes containing brine).

A galvanometer of the conventional round type, enclosed in a metallic sheath, served to indicate the temperature recorded by the resistance thermometers of the heat-measuring device. The galvanometer was calibrated in such a way as to make it possible to measure ground temperatures ranging from 60° to minus 50° C. The galvanometer was incorporated in a structure consisting of an unbalanced Wheatstone bridge located in a wooden box of 300 × 200 × 200 mm.

Located on an ebonite plate, which constituted the cover of the box, were the handles and levers of the heat-measuring device, the resistance thermometer switches and a rheostat, all of which were employed for the purpose of regulating the current fed into the entire system. The moisture of the ground on which the experiments were carried out was 33.7%.

The ground was continuously maintained in a frozen state, and its temperature at varying distances from the freezing column (temperature range) was recorded every four hours. After 30 days the temperature of the ground nearest to the freezing column reached minus 10°, at a point equidistant from the freezing column and the external edge of the ground - minus 6°, and at the periphery - minus 1°. The refrigerating system was subsequently disconnected. In order to determine the coefficient of the utilization of accumulated ground cold, the frozen ground was thawed. For this operation a solution with a temperature of 2° above that of the frozen ground adjacent to the freezing column, was applied under pressure by means of a centrifugal pump.

Sweet water in cisterns was cooled by the cold brine leaving the freezing column. It was possible to determine the amount of heat taken up by the brine through calculations involving the quantity and temperature of the cooled water. These calculations were made (taking into account the heat loss on the surface of the water tank) in accordance with the formula:

$$Q = g\gamma c(t_1 + t_2) \text{ kcal}$$

where g = amount of water cooled in kg;
γ = specific weight of water;
c = thermal capacity of water;
t_1 = temperature of water prior to cooling;
t_2 = temperature of water after cooling.

The total amount of cold lost in cooling of the water during the entire period of ground thawing process (Q_{useful}) constituted 69,000 kcal.

In conformity with formula (7) a calculation was made of the cold lost in freezing the experimental ground. Taking into account thermal inflow the total cold lost (Q_{total}) constituted 460,000 kcal.

Thus, even the most adverse conditions under which the experimental work on ground freezing has been carried out, the coefficient of the utilization of accumulated natural ground cold constitutes

$$K = \frac{Q \text{ useful}}{Q \text{ total}} \cdot 100 = \frac{69,000}{460,000} \cdot 100 = 15\%$$

It is thus possible for industrial purposes to accumulate in the ground quantities of cold to ensure an ample supply of natural cold for air conditioning purposes, particularly in the fish canning sections of fish-processing plants.

However, thermal losses are to be taken into account in the calculation of the cold requirements in order to ensure the necessary amount of cold for operating the conditioner throughout the entire summer season.

Initial Data for Calculation of Thermal and Cooling Capacities for Air Conditioning

In calculating the power requirements for air conditioning systems, which create an artificial climate in plants, it is necessary initially to assess the climatic conditions of the locality in which the systems will operate. Furthermore, it is important to know the temperature and humidity level existing in the plant.

For air conditioning in manufacturing plants it is necessary to calculate the

so-called "thermal and cooling loads" required for the preparation of air in the conditioners. Heat–humidity balances of the plant should also be made in calculating the parameter of the external air for the summer and winter seasons.

In calculating the thermal and humidity balance, factors having an influence on the state of the air existing within the plant, as well as factors affecting the air circulating from the conditioner into the plant, must be borne in mind.

In the winter season the thermal load is determined by the heat and humidity balance, while during the summer season the latter determines the cooling load. The volume of the incoming air is determined in conformity with these principles, the heat and humidity exchange is calculated, and subsequently, the required capacities of the heating and refrigerating equipment to be used in the air conditioning plant are determined by these principles. It is therefore necessary to determine the entire inflow of the heat to the plant where air conditioning is to be installed.

Inflow of Heat to the Plant across Obstructions

The calculation of losses, or of heat inflow which encounters obstructions, is based on the established formula:

$$Q = \pm \Sigma K \cdot F(t_{in} - t_{ex}) \text{ kcal/hour} \qquad (16)$$

where K = the overall coefficient of heat transmission in kcal/m^2 hour degree;
F = area of surface in m^2 corresponding to K;
t_{in} = air temperature in plant;
t_{ex} = external air temperature.

The external air temperature is calculated in accordance with the formula:

$$t_{ex} = 0.4\, t_{av} + 0.6\, t_{max}$$

Heat Flow into the Plant Originating from Solar Radiation

The calculation of heat originating from solar radiation, entering the plant via the walls and the roof, presents some difficulty in view of the periodic nature of such radiation. The values indicating the full heat current via the walls and the roof represent a combination of usual heat transmission plus solar radiation.

As a result of the heat capacity of walls and roofs the phenomenon of thermal inertia, i. e. a time lag (in phase) occurs during heat transmission. For example, a plastered brick wall 0.4 meters thick delays the maximal heat inflow by 12 hours. The quantity of heat current being emitted from walls at any time of the day can be determined by means of respective curves varying in relation to wall widths, conditions, and construction. However, for practical purposes it is advisable to employ an approximate method of calculation of heat transfer via walls and roofs, including solar radiation. In such a case the general equation (16) of heat transfer via obstructions assumes the following form:

$$Q = Q_{tr} + Q_{rad.} \text{ kcal/hr;} \qquad (17)$$

$$Q_{tr} = KF(t_{ex} - t_{in}). \qquad (18)$$

where $t_{ex} > t_{in}$;

$$Q_{rad} = F \varphi \varepsilon q_{rad} \quad (19)$$

where Q_{rad} = heat inflow originating from solar radiation in kcal/hour,

φ = part (in tenths) of the absorbed solar radiation transmitted to the interior of the premises, i.e., coefficient of heat permeation into premises,

ε = part (in tenths) of solar radiation absorbed by wall surfaces and

q_{rad} = observed intensity of solar radiation in kcal/m^2 hour.

The value of φ is approximately equal to 0.047 K.

By substituting the above for φ in equation (19), we obtain

$$Q_{rad} = 0.047 FK \varepsilon q_{rad} \quad (20)$$

The latter formula does not take into account the delay of the heat flow passing through the wall.

The values of the coefficient ε of absorption given in Degtyarev's Table (3) are as follows:

for a light-colored surface	ε	= 0.4
for a medium-colored surface	ε	= 0.7
for a very dark-colored surface	ε	= 0.9

The magnitude q_{rad} is obtained from special graphs compiled in relation to given latitude and season. For example, in the Leningrad oblast' fluctuations occur within the range as tabulated below:

Table

Time of day in hours	Geographical position						
	Northeast	East	Southeast	South	Southwest	West	Northwest
6	130	146	81.0	11.0	13.0	12.6	12.1
10	140	402	461	276	61.6	59.2	45.3
12	68.2	69.6	258.0	336.0	256.0	69.9	62.2
14	61.8	59.9	50.1	275.0	458.0	409.0	131.0
16	43.8	44.1	44.3	76.9	449.0	569.0	368.0

For walls that are not exposed to solar radiation Q_{rad} equals 0, and the heat current is merely represented by Q_{tr}.

The inflow of heat originating from solar radiation via glass surfaces has not been taken into account in our calculation as, during summer days, windows are protected against the sun by shutters.

Inflow of Heat and Humidity into a Plant as a Result of Infiltration

Although a plant structure may be airtight, it is possible, due to the effect of heat and wind pressure, for air to penetrate into a building via cracks and apertures and, to a lesser degree, via pores in the wall. This phenomenon is referred to as infiltration.

The quantity of heat, potent and latent, in kcal/hour which penetrates a building during summer periods, is calculated in accordance with the following equations:

$$Q_{pat.inf} = G_1 0.24 (t_{ex} - t_{in}) \quad (21)$$

$$Q_{total\ inf} = G (i_{ex} - i_{in}) \quad (22)$$

where G_1 = weight of air infiltration in kg/hour;

0.24 = specific heat capacity in kcal/kg degree;

i_{ex} = heat content of external air in kcal/kg of dry air;

i_{in} = heat content of internal air in kcal/kg of dry air;

The increase or decrease of air humidity in premises can be calculated in accordance with the following formula:

$$W = 0.001G(d_{ex} - d_{in}) \text{ kg/hour} \quad (23)$$

where d_{ex} = humidity of external air;

d_{in} = humidity of internal air.

Body Heat Emitted by Plant Personnel

The quantity of body heat emitted by man is dependent on weather conditions and the volume of labor performed. On the average a single worker emits 100-300 kcal/hour /11/.

The total heat emission patent by the entire plant personnel constitutes:

$$Q_{pat} = ng_{pat} \quad (24)$$

where n = number of personnel and

g = heat emission of one worker in kcal/hour.

Amount of humidity emitted by personnel:

$$W = 0.001\ nW, \quad (25)$$

where W = quantity of humidity emitted by one man in kg/hour.

Incoming Heat Originating from Other Sources

A significant quantity of heat enters a plant from electric lighting. This can be calculated in accordance with the equation:

$$Q_{el.l} = N\ 860 \quad (26)$$

where N = capacity of lighting equipment in kw.

Heat emanates also from electric motors and other equipment in a plant. The quantity of such heat depends on the duration of operation of such equipment, and its location, and on the coefficient of efficiency. The quantity of heat emitted by electric motors is calculated in accordance with equation (26)

Determination of Required Quantity of Air to be Supplied to a Plant by Air Conditioners

To determine the calculated and intermediate loads for cooling-freezing equipment, as well as to determine the required quantity of air to be supplied to the plant to be air conditioned, heat balances of the plant are to be compiled. Initially, parameters of external air are selected on the basis of Komarov's Tables /6/, or other tables, under which the conditioner must operate to ensure the required temperature and humidity in the plant.

Subsequently, all losses are calculated, and also the amount of heat flowing into the plant. On the basis of these data we calculate the required quantity of flowing air into the plant, and determine the heat balance of the premises:

$$\pm Q = \pm \Sigma Q_{pat} + W_{in} = \pm \Sigma Q_{pat} + \Sigma Q_{lat} \qquad (27)$$

where W = total humidity emission in kg/hour and
i_n = total heat content of water vapor in kcal/kg

Hence the direction of the heat-humidity reaction can be determined by the following relationship:

$$E = \frac{\Sigma Q_{pat}}{W} + \frac{\Sigma Q_{lat}}{W} = \frac{\pm \Sigma Q_{pat}}{W} + \frac{W i_n}{W} = \frac{\pm \Sigma Q_{pat}}{W} + i_n = \frac{\pm Q}{W}. \qquad (28)$$

The required quantity of inflowing air is determined, taking into account the direction of the reaction, and bearing in mind the following two conditions:

1. The establishment of an assumed abrupt change in temperature as in the case of cooling (summer) and heating (winter): for example, for cooling by means of a supply of air flowing into a lower zone $\Delta t = 3-5^{\circ}$ is used, while in the case of air flowing into a higher zone, $\Delta t = 6-7^{\circ}$,

For determination of air quantity it is necessary to determine the absorptive capacity of the air for the process of heat exchange, with a definite heat- humidity relationship $E = \frac{\pm Q}{W}$

According to the heat balance equation we obtain:

$$G(i_2 - i_1) = G \Delta i = Q_{total} \quad \text{kcal/hr}$$

and

$$\frac{G(d_2 - d_1)}{1000} = 0.001 G \Delta d = W \quad \text{kg/hr}$$

from which we find the required quantity of fresh air inflow in kg per hour.

$$G = \frac{Q_{total}}{i_2 - i_1} = \frac{Q_{total}}{\Delta i} \qquad (29)$$

and

$$G = \frac{W}{0.001 (d_2 - d_1)} = \frac{W}{0.001 \Delta d} \qquad (30)$$

In a case where the humidity emission in a plant is not extensive, it would be difficult, according to the curves indicated by Degterev /3/, to find Δd with sufficient accuracy. In such a case it is advisable to determine Δi, and to use it to calculate the quantity of air in accordance with the formula (29).

If $d_2 = d_1$, as is frequently observed in fish-processing plants located in humid zones (for instance, in the Leningrad oblast'), and $\Delta d = 0$, the total heat emission in the premises represents potent heat ($Q_{\text{total pat}}$) and the air quantity can be calculated in the usual manner:

$$Q_{\text{total pat}} = Gc_{av}(t_2 - t_1) \tag{31}$$

and

$$G = \frac{Q_{\text{total pat}}}{c_{av}(t_2 - t_1)} = \frac{Q_{\text{total pat}}}{c_{av}\Delta t} \text{ kg fresh air per hour} \tag{32}$$

Using this formula to calculate the air required in the event of a high humidity emission, we allow for an error of 7 ~ 5-6%.

2. When information is available in the air parameters that are to be maintained in the working zone, and on the parameters of the air to be supplied to the premises (i_2 and i_1 are known), the quantity of the fresh air required can be determined on the basis of equation (29):

$$G = \frac{Q_{\text{total}}}{\Delta i} \text{ kg/hour}$$

In cases, where there are no particularly harmful emissions in the air of a plant, and when it is possible to purify the used air by the usual means (filters, purifying chambers), it is advantageous to utilize recirculated air (reversed) mixed with fresh air, with a view to employing more economical air-conditioning equipment. The permitted quantity of such air depends on the working capacity of the plant and, in conformity with established norms, constitutes a minimum of 10% of the total volume of the supplied air.

Air Conditioning Systems

The constancy of the air parameters in a plant is established by the co-ordinated action of a whole series of instruments and apparatus. This co-ordination represents the system of air conditioning.

The selection of elements of an air-conditioning system, and their combined operational effect, depends on the absolute magnitudes and on the variation of heat balances, humidity and gases, and the extent of their interconnection.

The modes of operation of air-conditioning systems, as described in the literature devoted to the problems of air conditioning, are distinguished by their seasonal application: summer, winter and transitional. The different systems of air conditioning are already well established in their application in residential and public premises.

Regarding premises of the fish-processing industry, such interrelationship between heat balances, humidity, and gases is possible, completely independent of, and unaffected by, external weather conditions. Indeed, in the production apparatus, generation of heat may be such as to render the variations of the external temperature of little importance to the heat balance of the premises.

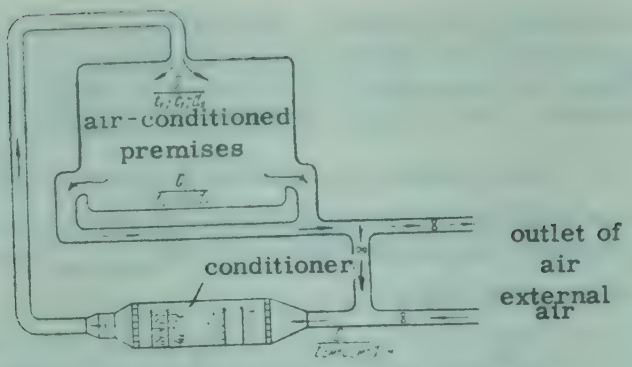

Figure 4. Diagram of air conditioning apparatus

There are descriptions /3, 9, 11, 13/ of the construction of a whole series of air-conditioning systems and their respective calculations, which render their repetition in this work unnecessary. In fish-processing plants it is advisable to apply the combined systems as shown in Figure 4.

The basic aggregates of air conditioning systems, the so-called conditioners represent a complex combination of various heat exchange apparatus intended for measurement of air conditions. In conjunction with this the agent, conveying heat to the air (heat carrier), or extracting heat from the air (cold carrier), is in most cases either water or an aqueous solution of salts.

According to their construction the heat exchange apparatus are distinguished as follows:

1) Apparatus with a direct contact with the cold carrier (moist type);

2) Apparatus in which the heat exchange operates via the wall separating the air from the cold carrier (dry type).

The apparatus of the first type, which is the one most widely in use, includes the chambers of air irrigation utilizing either water or solutions.

We consider that for fish-processing plants, where it is desirable that natural cold be utilized, the use of the apparatus of the first type is preferable. A concentrated solution of potassium chloride is the cold-carrying agent in this system, and is similarly employed in the process of ground freezing in winter and in the utilization of accumulated cold for air conditioning.

Figure 5 represents in principle a diagram of the utilization of natural cold for air conditioning of fish processing plants.

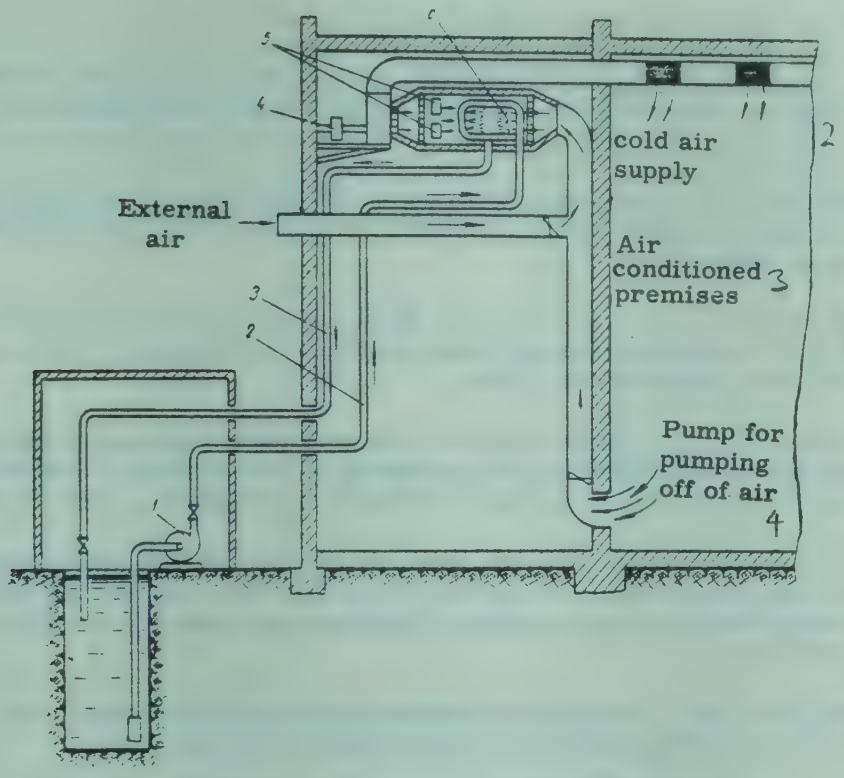

Figure 5. Diagram of utilization of natural cold for air conditioning in fish-processing plants

1—pump; 2--pipe for cold brine; 3—pipe for warm brine; 4—ventilator; 5--separator; 6—air cooler.

CONCLUSIONS

1. Air conditioning in fish-processing plants is an indispensable measure favoring the creation of ideal conditions for preserving the quality of the fish in the course of processing by regulating the temperature and the relative humidity of the air in the plant.

2. For supplying cool air to plants, it is recommended that the natural cold accumulated in the ground during the winter, be utilized.

The accumulation of natural ground cold in winter can be realized in any region where in winter the external air temperature is sufficiently low.

3. It was shown experimentally that the coefficient of utilization of accumulated natural ground cold reaches 15%.

In accordance with calculations made by the author, the cost of 1,000 kcal of natural cold utilized for air conditioning will be approximately 2.5 times less than the cost of artificially produced cold.

4. The introduction of air conditioning into industrial plants is one of the links in the chain of uninterrupted cooling for the preservation and processing of fish.

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CHANGES IN WEIGHT AND MOISTURE OF FISH PRESERVES IN TOMATO JUICE DURING PREPARATION AND STORAGE

(Izmenenie vesa i vlagosoderzahniya ryby v protsesse prigotovleniya i khraneniya konservov s tomatnym sousom)

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The weight ratio of fish to juice in preserves is one of the basic indicators of their quality, and is dependent on the quantities of stewed fish and juice per can and also on the extent to which the fish is stewed in oil prior to canning. However, it is not sufficiently well known to what extent the above-mentioned factors influence the ratio of the fish to juice during the canning of various kinds of fish.

This article describes the results of experiments carried out by the author on the preparation of preserves, using fish stewed for different lengths of time and with varying proportions of fish and juice used for canning. The experiments were carried out in the canning plant of the Fish Combine im. Mikoyan, in Astrakhan, with seven different kinds of fish (white sturgeon, bream, sturgeon, sevruga, carp, catfish and pike perch).

The preserves were divided into size No 8 cans with a capacity of 350 g. Evisceration and salting, preparation of the tomato juice, sterilization and incubation were carried out in accordance with technological instructions. The fish were stewed in olive oil on a steam-oil stove at a temperature of 140-150°C, and the duration of stewing was varied in order to achieve varying degrees of stewing.

In canning experiments carried out on carp, pike perch and bream, the loss of fish weight during stewing was from 16.1 to 19.1%. In experiments on catfish the loss of fish weight was from 16.7 to 20.6%, and on sturgeon, sevruga Acipenser stellatus and white sturgeon, from 18.5 to 21.7 % of eviscerated fish.

The loss of fish weight during stewing was carefully controlled by weighing every griddle with fish, both before and after stewing. Samples were taken from every batch of fresh and stewed fish in order to determine the moisture content. In each experiment carried out on the preparation of preserves, we selected only griddles holding equal amounts of stewed fish. (The fluctuations in loss of fish weight in fish taken from various griddles were within the range of ± 0.1%).

In order to estimate the relation of changes in fish weight to the quantity of water extracted, we stewed single pieces of pike perch and sturgeon in order to obtain a weight loss from 14 to 15 % up to 22 - 23 %. For this purpose, each slice of fish was marked and weighed, and then put on a griddle and stewed in the usual way. The stewed pieces of fish were then weighed again, and submitted for chemical analysis.

The samples of fresh fish for analysis were thin slices cut from each piece of fish prior to stewing. Experiments were carried out separately on every piece of fish in order to obtain precise data.

We estimated that pieces of different sizes (irrespective of height) taken from different parts of the body and of different chemical composition, should vary in different ways:

The ratio of stewed fish to tomato juice, when canned in size No 8 tins in % of net weight to the whole preserve was as follows:-

1) In Cyprinidae preserves 60:40 and 66:34 (with 209 and 230 g of fish and 141 and 20 g of juice respectively).

2) In Acipenseridae preserves 66:34 and 74:26 (with 230 and 260 g of fish and 120 and 90 g of juice respectively).

In order to obtain reliable results, the experiments were carried out on batches of preserves using all the tested methods of stewing, and the various ratios of stewed fish to tomato juice were repeatedly performed in series (from 2-3 up to 5-6 batches)

All preserves under examination were kept in the usual storehouse for 6 months.

Analyses were carried out on the preserves during the process of preparation (after sterilization, and incubation in a thermostat), as well as every month during storage. During the analyses of the preserves the weight-ratio of fish to juice, and to the moisture content of fish and juice were defined. The weight ratio of fish to juice was established by a standard method. In order to obtain more precise and comparable results, the following additions were made to the accepted testing methods:

1) Prior to testing, the cans of preserves were kept in an air or water thermostat at a temperature of 35°-36°C in order to provide the same temperature conditions of testing in each case, and in order to facilitate the drainage of juice from the cans and permit a better separation of juice from the fish.

2) The duration of drainage of juice from the tilted can was the same in every case, i.e., 60 minutes. It was established upon observation of the drainage of juice from cans that during the first 15 minutes 78.3% of the juice was drained, during the following 15 minutes, 14.1%, during the next 15 minutes, 5.4%, and during the last 15 minutes, 2.2%. After that the drainage was practically nil, so that the quantity of juice collected in the subsequent 30 minutes was only a fraction of 1%.

In every case the samples of preserves for analysis consisted of the contents of three cans, all examined separately in order to discover possible variations of contents in each tin. The average contents of the sample on the basis of the results of each analysis were calculated.

Altogether, 53 batches of preserves, containing the seven kinds of fish already mentioned, were examined. The total quantity of cans of preserves examined (after sterilization, incubation in a thermostat, and during further storage) was 970.

Results of Experiments

Weight changes of fish in cans

The results of many observations of changes in fish and juice weights in every batch of preserves during sterilization, thermostatic incubation and storage cannot be fully shown in this article. Table I, therefore, presents only the average data which characterize the changes in weight of different kinds of fish in cans, depending on the extent of stewing and on the ratio of fish to tomato juice upon canning.

Table I

Changes in relative weight of fish in preserves

Kind of fish	Loss in fish weight in % during stewing	Ratio of fish weight and juice during canning	Fish content in % of net weight of preserves								
			Before sterilization	After sterilization	After thermostatic testing	After storage (months)					
						1	2	3	4	5	6
Carp	16.6	60:40	60	73	76	75	73	75	75	74	77
	18.7	60:40	60	70	74	76	79	79	—	—	—
	16.6	66:34	66	79	78	79	80	81	82	80	81
Bream	16.1	60:40	60	81	76	77	78	77	77	79	80
	16.1	66:34	66	85	86	82	83	82	82	81	86
Pike perch	16.4	60:40	60	73	75	77	73	79	74	75	81
	18.3	60:40	60	72	73	75	77	77	—	—	—
	16.6	66:34	66	82	79	83	82	82	82	80	82
Catfish	16.9	60:40	60	65	64	62	66	66	65	65	68
	19.9	60:40	60	68	65	64	64	67	—	—	—
	16.9	66:34	66	70	76	76	72	71	76	72	75
Sturgeon	20.4	66:34	66	73	71	71	72	73	—	—	—
	21.6	74:26	74	72	70	72	73	73	—	—	—
Sevruga	20.8	66:34	66	72	71	71	73	71	—	—	—
	20.7	74:26	74	80	80	80	81	79	—	—	—
White sturgeon	20.8	66:34	66	73	74	73	73	75	—	—	—
	21.7	74:26	74	81	79	82	80	78	—	—	—

The weight of fish in preserves generally changes during the process of sterilization, and, as a rule, increases. Only in some experiments carried out on the preparation of sturgeon preserves was a decrease in fish weight observed after sterilization. Changes in fish weight during sterilization result from a process of diffusion between fish and juice, and also from capillary absorption of water from the juice by the outer layers of fish that damage during stewing. Apparently a partial swelling of fish proteins also takes place.

In the case of Cyprinidae preserves prepared by filling 60% stewed fish per can, the fish weight during sterilization increased from 66 to 81% and the weight of juice decreased correspondingly from 40% to 34-19%. The highest absorption of juice was observed in bream (81%), and the lowest in catfish (66%). In pike perch and carp the weight increase was the same (up to 73%). Increasing the extent of stewing from 16-17% up to 19-20% showed little effect on changes of fish weight during sterilization of preserves. The average weight of fish in different preserves prepared varied only by 1-3%.

By increasing the canning content of stewed fish to 66% the fish weight after sterilization reached 70-85%, and the weight of juice decreased from 34% to 30-15%. As in the first case, the greatest increase was observed in bream (up to 85%), and the lowest in catfish (up to 70%). In preserves of pike perch and carp, the weight of fish reached 79-82%.

In the case of Acipenseridae preserves prepared by filling 66% of stewed fish per can, the fish weight increased after sterilization from 72 to 73% on the average, and the weight of juice decreased from 34% to 27-28%. By increasing the canning content of stewed fish to 74%, a weight increase of up to 80-81% was observed in sevruga and white sturgeon after sterilization. In the case of sturgeon, on the contrary, a weight decrease to 72% was noted. It should be emphasized that in the analysis of this batch of sturgeon preserves, a decrease in fish weight was observed in almost every can examined, which would confirm the validity of the average data obtained. The decrease in fish weight in this case can be explained by the intense exudation of fat from the fish during heating. The observations indicated that after sterilization there is a considerable increase in the quantity of fat in the juice.

During the thermostatic incubation of preserves and their subsequent storage in the storehouse, the relative weight of preserved fish showed practically no change. The slight fluctuations in weight observed (Table I) were probably due to individual differences in size, configuration, structure and chemical composition of the pieces of fish. The absence of any regularity in these fluctuations indicated that during storage of preserves after sterilization, the diffusion processes between fish and juice are reduced.

The observations indicated that the contents of fish in individual cans of one batch vary considerably.

The range of fluctuations in fish weight in separate cans, established under analysis of preserves from different batches, is given in Table II.

From the data in Table II it can be seen that the degree of stewing has no clear influence on the amplitude of fluctuations in fish weight in carp preserves (17-18%), and pike perch (19-21%); but in the case of catfish preserves, an increase in stewing (from 16-17% up to 19-20%) leads to a strong decrease in fluctuations in the weight of canned fish (from 20 to 11%), and a considerable increase in the lower limit of fish content in preserves (from 54 to 58%) which, in production, is very important. Increasing the content per can of fish stewed to a uniform extent has practically no influence on the amplitude of fluctuations in fish content of individual cans of preserves of carp and catfish, but in preserves of other kinds of fish, and especially of Acipenseridae, such an increase leads to a considerable decrease in fish weight fluctuations.

In order to obtain an idea of the quantity of preserves having a certain ratio of fish to juice, when different quantities of stewed fish were used, the samples of preserves examined were divided into three groups:- 1) with fish content of less than 70%; 2) with fish content in the range of 70-80%; 3) with fish content of more than 80%, and the proportion of every group to the total amount of preserves examined was calculated. The results are shown in Table III.

The analysis of data given in Table III enables us to observe that the highest percentage comes from preserves of pike perch, carp and bream, with the standard optimal ratio between fish and juice of (70/30 to 80/20), by stewing of 16-17%, and by canning of 60% per can. In the case of catfish prepared under these conditions, we obtained preserves with a fish content of less than 70%. This meant that the preserves were nonstandard. Increasing the extent of stewing of

catfish to 20% resulted in a marked reduction in fluctuations of fish content in separate cans (see Table II); yet we did not obtain the required fish content in preserves, which was supposed to be 60% of stewed fish per can.

Table II

Fluctuations in relative weight of fish in separate cans of preserves according to the different extent of stewing and canning

Kind of fish	Loss in fish weight during stewing in %	Stewed fish in can in %	Fish content in preserves in %		
			Minimum	Maximum	Difference
Carp	16.6	60	66	84	18
	18.7	60	66	83	17
	16.6	66	70	87	17
Pike perch	16.4	60	65	84	19
	18.3	60	64	85	21
	16.6	66	74	87	13
Bream	16.1	60	67	85	18
	16.1	66	76	90	14
Catfish	16.9	60	54	74	20
	19.9	60	58	69	11
	16.9	66	65	86	21
Sturgeon	20.4	66	61	81	20
	21.6	74	69	77	8
Sevruga	20.8	66	65	80	15
	20.7	74	77	85	8
White sturgeon	20.8	66	63	84	21
	21.7	71	74	83	9

Better results were obtained by increasing to 66% the fish content per can with stewed catfish. But even under these conditions a considerable amount of catfish preserves contained less than 70 % of fish (25 % of all cans examined). The cause of this was probably that in the experiments on the preparation of catfish preserves with the increased fish content per can, the stewing was not sufficient (16.9%).

In the case of Acipenseridae preserves, and especially sturgeon, when canning with 66% of broiled fish per can, a considerable number of cans (20-40%) had less than 70% fish content. By increasing the canning content of stewed sturgeon to 74% per can, we obtained 12.5% of cans containing less than 70% of fish, and 87.5% of cans containing 70-80% of fish. In identical experiments carried out on sevruga and white sturgeon, no preserves were obtained with a fish content of less than 70%; but half the quantity of preserves contained more than 80% of fish. Thus, in the case of sevruga and white sturgeon preserves, the content of stewed fish in each can should be less than 74 %.

In order to define the optimal quantity of stewed fish content required per can, in order to obtain the maximum output of preserves with a fish content in the range of 70-80%, we have to establish the extent of the relative change in fish weight during the processes of sterilization and thermostatic incubation of the preserves.

Table III

Relationship of preserves with varying fish content obtained by various degrees of canning stewed fish

Loss in fish weight during stewing in %	Norm of fish and juice canning in %	Kind of fish	In % of the total quantity of tested tins with different fish content		
			Less than 70%	70-80%	More than 80%
16.1-17.3	Fish 60 Juice 40	Carp	10.5	81.4	8.1
		Pike perch	7.8	80.5	11.7
		Bream	1.0	74.0	25.0
		Catfish	80.0	20.0	-
17.5-20.6	Fish 60 Juice 40	Carp	13.0	74.0	13.0
		Pike perch	9.1	83.0	7.9
		Catfish	100.0	-	-
16.1-17.3	Fish 66 Juice 34	Carp	-	60.4	39.6
		Pike perch	-	43.7	56.4
		Bream	-	14.6	85.4
		Catfish	25.0	66.7	8.3
20.4-20.8	Fish 66 Juice 34	Sturgeon	39.7	58.9	1.4
		Sevruga	23.0	77.0	-
		White sturgeon	19.5	75.0	5.5
20.7-21.7	Fish 74 Juice 26	Sturgeon	12.5	87.5	-
		Sevruga	0	54.2	45.8
		White sturgeon	0	45.8	54.2

In order to obtain preserves with a fish content of 70-80%, the fish weight in preserves should increase by means of juice absorption by a minimum of 17.2% and a maximum of 34%, when the cans are filled with 60% of stewed fish. But, upon canning with 66% of stewed fish, the minimum increase should be 6.5%, and the maximum, 21.7%. When canning with 74% of stewing fish, both an increase in weight of about 7.7% and a decrease of about 5.8% are possible.

Weight changes in stewed fish during sterilization, thermostatic incubation and storage, noted in our experiments, are recorded in Tables IV and V.

According to the facts mentioned in Table IV, one can see that by stewing to 16-17% and by filling the cans with a quantity of 60%, the weight of pike perch, carp, and bream increases by juice absorption on the average by about 22.5-35.4% during sterilization; this enables us to obtain preserves containing not less than 70% of fish.

In the case of catfish preserved prepared under the same conditions, the fish weight increased only by 9.1%, and, as a result, a large amount of preserves contained less than 70% of fish and were nonstandard. The increase of weight in catfish can hardly be explained by the slight possibility of juice absorption as compared with other fish. We presume that, during sterilization, a large amount of fat is discharged into the juice which, to some extent, offsets the increase in weight caused by juice absorption. This supposition is borne out by observations on the change of fat content of fish and juice during sterilization of preserves.

Table IV

Weight changes in stewed fish during sterilization, thermostatic testing, and storage of Cyprinidae preserves

Loss in fish weight after stewing in %	Norms of canning of fish and juice in %	Kind of fish	Fish weight in preserves in % initial weight of stewed fish									
			After sterilization		After thermostatic testing		After storage					
							1 month		2 months		3 months	
			Fluctuations	Average	Fluctuations	Average	Fluctuations	Average	Fluctuations	Average	Fluctuations	Average
16.1—17.3	Fish 60 Juice 40	Carp	111.0—137.3	122.5	117.2—140.7	127.8	117.2—135.4	125.8	115.3—128.7	121.5	115.3—140.7	124.9
		Pike perch	110.5—132.1	122.5	115.3—134.0	126.3	117.2—142.1	128.2	115.3—130.6	122.0	122.5—144.0	131.6
		Bream	128.7—140.7	135.4	112.0—138.7	127.8	120.6—134.0	128.2	122.0—137.3	130.1	117.2—142.1	129.2
		Catfish	100.4—122.0	109.1	91.9—122.0	106.2	93.7—124.4	103.8	101.9—120.6	111.0	100.4—117.2	111.0
17.5—20.6	Fish 60 Juice 40	Carp	111.0—123.9	117.2	117.2—130.6	124.4	117.2—134.4	127.3	120.6—138.7	132.1	128.7—135.4	132.1
		Pike perch	108.6—137.4	121.5	115.3—134.0	123.0	120.6—130.6	124.9	117.2—144.0	128.7	122.0—137.3	128.7
		Catfish	110.5—114.8	112.9	104.3—113.8	108.8	101.4—110.5	105.8	97.0—114.8	106.7	105.3—114.8	111.5
16.1—17.3	Fish 66 Juice 34	Carp	109.6—130.9	120.4	106.5—126.1	118.7	109.6—126.1	120.4	118.7—124.8	121.3	110.9—127.8	123.0
		Pike perch	112.6—132.2	124.3	115.7—127.8	120.0	120.0—130.0	126.1	116.9—129.1	123.9	121.7—130.9	124.8
		Bream	126.1—133.9	129.1	126.1—132.2	130.5	121.7—127.8	125.2	123.5—130.9	126.5	116.8—136.9	124.3
		Catfish	98.7—113.9	106.5	103.5—123.0	115.7	104.8—127.8	115.2	101.5—118.7	109.6	100.4—116.9	107.8

Table V

Weight changes in stewed fish during sterilization, thermostatic testing, and storage of Acipenseridae preserves

Loss in fish weight during stewing in %	Norms of canning of fish and juice in %	Kind of fish	Weight of fish preserves in % of its total weight after stewing									
			After sterilization		After thermostatic testing		After storage					
							1 month		2 months		3 months	
			Fluctuations	Average	Fluctuations	Average	Fluctuations	Average	Fluctuations	Average	Fluctuations	Average
20.4—20.8	Fish 66	Sturgeon	98.7—123.9	111.3	95.6—116.9	108.7	92.6—118.7	107.8	98.7—121.7	109.1	92.6—115.7	109.6
	Juice 34	Sevruga	101.5—121.7	110.0	103.4—116.9	108.3	101.5—118.7	108.3	101.5—120.0	110.4	103.4—112.6	108.3
		White sturgeon	100.4—127.8	111.7	104.8—121.7	112.2	105.2—116.9	110.4	95.6—123.0	110.9	100.4—123.0	113.5
20.7—21.7	Fish 74	Sturgeon	95.4—98.1	96.9	92.7—96.9	94.2	92.7—99.6	96.5	94.2—102.3	97.7	97.3—98.1	97.7
	Juice 26	Sevruga	103.8—110.4	108.1	105.0—110.4	107.3	105.0—110.4	106.8	103.4—113.1	108.5	103.4—108.8	105.8
		White sturgeon	108.8—110.4	109.2	102.3—107.7	105.8	108.8—110.4	110.0	106.2—108.8	108.1	99.6—108.8	104.6

By increasing the extent of stewing from 16 – 17% to 20%, the increase in weight of pike perch and carp was slightly reduced, and was between 17.2 and 21.5%. One may suppose that in this case the prolonged stewing of fish resulted in a stronger denaturation of proteins, thus decreasing the possibility of swelling and, consequently, decreasing the possibility of juice absorption by the stewed fish. In the case of catfish, on the other hand, the increased stewing leads to some weight increase, on the average from 9 - 13%.

This phenomenon can be explained by the fact that prolonged stewing causes a greater discharge of fat before canning, i.e., the discharge of fat during sterilization was less. The weight increase may possibly be attributed to the fact that, after the discharge of fat, the absorptive capacity of the protein mass increased.

In the case of catfish the increased absorption of juice conduced by increasing the extent of stewing was not sufficient and did not give the desired increase in fish weight when canning with 60% of stewed fish. By increasing the quantity of fish to 66% per can by stewing to 16 - 17% the weight increases in Cyprinidae fish of all kinds, with the exception of catfish, were considerable greater than were calculated (20.4 - 29.1%) and a larger amount of preserves containing more than 80% of fish was obtained. Simultaneously, the weight increase in fish when canning with 66% of stewed fish was less than when canning with 60%. This indicated a decrease in the absorptive capacity of fish by increasing the fish content per can. The increase was probably caused by tighter packing of fish in the cans which, in turn, caused a deterioration of contact between fish and juice.

Upon examination of data on weight changes in Acipenseridae, as shown in Table V, the following must be stressed. By canning 66% of stewed Acipenseridae per can, the increases in fish weight during sterilization and thermostatic incubation were on an average 8 - 12% instead of the required 14%; minimal absorption of juice was 6.5%, and maximal 21.7%. In 23% of cans of sevruga and white sturgeon preserves, the increase in fish weight was less than the minimum required, i.e., less than 6.5%. In 40% of sturgeon preserves, instead of an increase, a decrease in weight of up to 5% was observed.

In cases where the weight of canned fish increased to 74%, the fluctuations in fish weight in separate cans were less, and were at most 8 - 9% of the weight of the stewed fish. When canning with 66% stewed fish the fluctuations reached 15 - 21%. On the average, filling with 74% of stewed sevruga or white sturgeon per can produced an increase in fish weight of 6 - 9% after sterilization and thermostatic incubation. However, in the case of sturgeon preserves, there was a decrease to 3 -5%. It was demonstrated that the extent of changes in fish weight depended on the amount of stewed fish put into each can. This quantity increases with the decrease in the absorptive capacity of the fish.

Observations made on a large quantity of cans do not confirm the general opinion that in preserves made from fat Acipenseridae, the body weight of fish decreases after sterilization, due to loss of fat.

Since the fat content of each specimen of Acipenseridae is different, there are cases of loss of weight in sevruga or white sturgeon during sterilization which are similar to our observations on sturgeon. In general however, in the case of Acipenseridae, a weight increase upon sterilization is typical. It is difficult to establish the precise weight of every kind of stewed Acipenseridae fish in preserves According to our calculations, during sterilization and thermostatic incubation, the fish weight generally increases by up to 2%; this should be taken into account when establishing a norm for canning stewed fish. Thus, in order to obtain a general fish content of 73% in preserves, the optimal filling of Acipenseridae in size No 8 cans should be $\frac{350 \cdot 73 \cdot 100}{100 \cdot 102} = 250$ g. Thus the ratio of fish to juice when canning should be 71:29.

The above-mentioned results of observations clearly indicate that the extent of stewing and filling should differ in every kind of fish.

In order to obtain preserves with a fish content of not less than 70% and, if possible, of not more than 80%, the filling norm should be as follows:-

Type of fish	% of stewing	Ratio of fish weight to juice at the time of canning
Pike perch, carp, bream	17.5	60 : 40
Catfish	20	66 : 34
Sturgeon, sevruga, white sturgeon	20	71 : 29

The filling norms mentioned for pike perch, carp and bream coincide with those accepted in the industry. As for catfish and Acipenseridae, we proposed an increased canning content and, in the case of catfish an increase also in the degree of stewing. These increases were tried out at the Astrakhan Fish Factory, and showed good results.

It is interesting to consider the weight changes in fresh eviscerated fish during the production of preserves. The relevant facts are demonstrated in Figures 1 and 2.

The curves in Figures 1 and 2 indicate that in preserves made from fat fish and catfish, despite swelling and absorption of juice by stewed fish during sterilization, the fish weight as compared with the initial weight of fresh eviscerated fish was generally less than 10 - 20% and, in some cases, even up to 30%. In preserves of fish with average fat content, or lean Cyprinidae (carp, bream, pike perch) the weight of fish is the same, and sometimes surpasses (by 3-5%) the initial weight of fresh fish.

Changes in Water Content of Fish and Juice

Observations were carried out on fish samples taken from a number of griddles during the stewing of different batches, and also on individual pieces of fish.

According to the data obtained on changes in fish weight and water content before and after stewing we calculated the moisture loss in % of the initial moisture content in fresh fish.

Changes in moisture content, dependent on the extent of stewing observed in separate pieces of fish are indicated in Table VI and Figure 3. Corresponding data obtained from the average samples taken from griddles are recorded in Table VII.

According to Table VII, the amount of moisture lost increased due to more prolonged stewing. In experiments on separate pieces of pike perch and sturgeon, the fluctuations of moisture content were greater (Table VI) than during observations on average samples of these species of fish, taken from griddles (Table VII), but the average moisture loss was very similar in both cases.

The wide variation noted during observations made on separate pieces were probably caused by individual differences (Fig. 3) in size, form, and fat content of each piece of fish. The differences disappear in average samples taken from griddles.

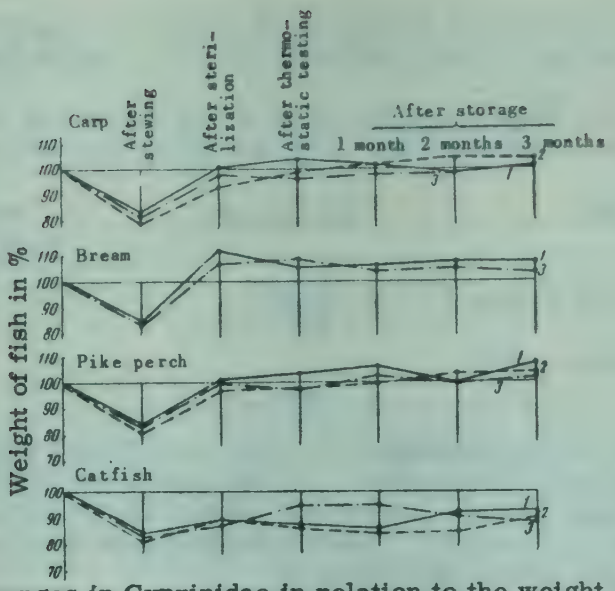

Figure 1. Weight changes in Cyprinidae in relation to the weight of fresh eviscerated fish during process of preparation and storage of preserves
1 - Extent of fish-stewing 16.1 - 16.9%, canning norm 60%;
2 - " " 18.3 - 19.9%, " " 60%;
3 - " " 16.1 - 16.8%, " " 60%

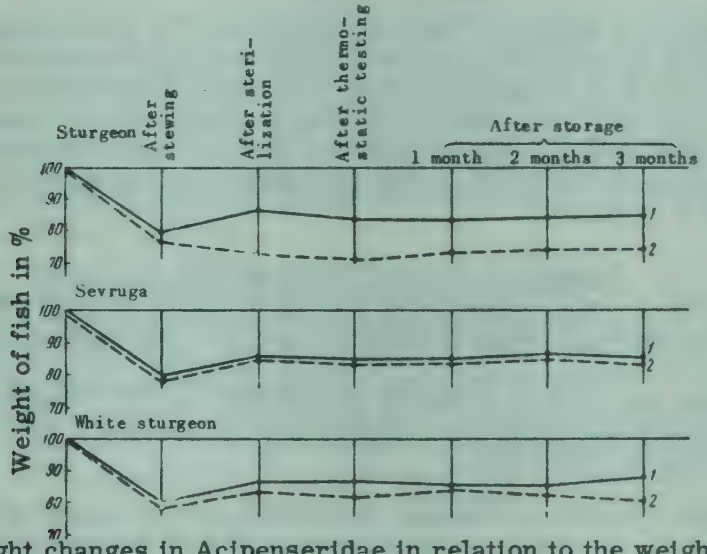

Figure 2. Weight changes in Acipenseridae in relation to the weight of fresh eviscerated fish during the process of preparation and storage of preserves
1 - Extent of fish stewing 20.4 - 20.8 %, canning norm 66%;
2 - " " 20.7 - 21.7%, " " 74%;

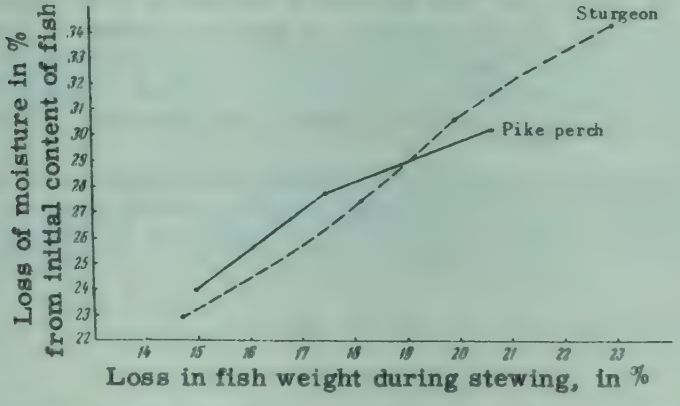

Figure 3. Moisture loss in pike perch and sturgeon with various degrees of stewing

The volume of moisture loss varied in different species of fish exposed to the same degree of stewing. In our experiments we observed the lowest moisture loss in sturgeon and pike perch. The moisture loss in these fish, when stewed at 15%, was 23 - 24%, and when stewed at 18 - 20%, was 27 - 31%.

Table VI

Changes in moisture content in fish observed in experiments on single pieces of fish with various degrees of stewing

Losses during stewing in %	No of experiments	Moisture content in fish in %		Moisture loss in % from its initial content in raw fish	
		Raw fish	Stewed fish	Fluctuations	Average
			Pike perch		
From 14.4 to 15.9 (average 15.0)	12	78.36	69.65	21.1—27.0	23.9
From 16.0 to 19.0 (average 17.4)	39	77.97	68.41	23.7—33.0	27.6
From 19.1 to 22.8 (average 20.6)	30	78.31	68.71	25.7—34.5	30.0
			Sturgeon		
From 13.3 to 15.8 (average 14.7)	6	67.91	63.87	13.1—25.6	22.9
From 17.2 to 19.0 (average 18.1)	8	68.22	60.51	23.9—33.1	27.3
From 19.1 to 21.4 (average 20.4)	24	68.79	60.24	24.5—38.9	30.6
From 21.7 to 24.5 (average 22.8)	42	66.26	57.71	24.8—41.8	34.1

But the moisture loss in bream, carp and catfish during 16 - 17% stewing was 33%. Similarly, in 18 - 20% stewing of sevruga and white sturgeon, the water loss was 32 - 34%, and in the case of carp and catfish, about 40 %. With 21 - 22% stewing of Acipenseridae, the weight loss was on the average 34% for sturgeon, and for white sturgeon and sevruga 41 - 42%. Analysis of these data indicated that in the case of fat Acipenseridae during stewing, the extraction of water from Cyprinidae is easier and more intensive. One may deduce that the slower extraction of water from Acipenseridae is connected with the melting of fat of these fish during stewing which reduced water extraction. In our opinion, the difference in moisture loss in every type of fish during stewing depends not only on their chemical composition but also on the histological structure of the fish meat.

It should be noted that in Cyprinidae fish the total volume of moisture loss exceeded the weight loss of fish (1.1 - 1.5 times). This can be explained by the fact that during stewing, absorption of oil is apparent simultaneously with the loss of moisture by the fish.

In Acipenseridae the extent of moisture loss and loss of fish weight during stewing are similar, which probably indicates that, in this case, the discharge of fat and the absorption of oil are practically the same.

In Table VIII are given the average data which characterize the changes in water content of fish during sterilization of preserves made from various types of stewed fish, and with differing canning ratios of stewed fish to tomato juice.

During the process of sterilization of preserves a moisture increase in fish, due to absorption of tomato juice, took place in all cases. Analyses carried out on fish and juice separately indicated a sufficiently clear relation between increase in moisture content in fish and decrease in juice.

Table VII

Changes in moisture content observed during investigations on average samples of fish taken from griddles with various degrees of stewing

Kind of fish	Losses during stewing of fish	No of experiments	Moisture content in the fish, in %		Moisture loss in % of moisture	
			Raw fish	Stewed fish	Fluctuations	Average
Carp	16.4 - 16.8 (average 16.6)	3	78.43	63.92	32.5–33.9	33.3
Carp	18.4 - 19.1 (average 18.7)	2	78.27	59.71	38.4–40.1	39.2
Bream	16.1	1	78.53	63.91	—	33.1
Pike perch	16.3-16.6 (average 16.4)	2	78.15	71.25	25.2–25.3	25.3
Pike perch	17.5-18.9 (average 18.3)	5	78.34	67.31	28.9–33.4	31.2
Catfish	16.7-17.3 (average 16.9)	3	79.85	65.80	32.2–34.2	32.9
Catfish	19.1-20.6 (average 19.9)	2	77.97	58.63	37.7–43.6	40.7
Sturgeon	18.5-19.6 (average 19.1)	2	67.96	63.14	24.6–28.0	26.3
Sturgeon	20.7-21.6 (average 21.1)	3	67.36	57.56	33.2–35.4	34.1
Sevruga	19.7-20.2 (average 19.9)	2	70.35	60.44	32.5–32.7	32.6
Sevruga	20.7-21.7 (average 21.2)	3	71.66	54.08	39.0–43.3	41.8
White sturgeon	18.7-20.2 (average 19.5)	2	71.14	59.67	31.9–35.6	33.8
White sturgeon	21.6-21.7 (average 21.7)	3	71.54	55.29	40.6–40.8	40.7

Thus, according to the data given in Table VIII, the Cyprinidae fish showing the highest absorption of moisture during sterilization were bream and carp and of Acipenseridae, white sturgeon and sevruga. An increase in the extent of stewing of all fish except white sturgeon, is accompanied by an increased swelling of stewed fish during sterilization of preserves. Thus, with prolongation of stewing of Cyprinidae fish from 16-17% to 18-20%, the quantity of moisture absorbed increased in carp from 26.6% to 30.6%, in pike perch from 19.1% to 25.6%, and in catfish from 15.2% to 31.5%.

By increasing the degree of stewing from 19 - 20% to 21 - 22% moisture absorption increased in sevruga from 19.3% to 26.4% and, in sturgeon, from 15.0% to 22.9%.

Table VIII

Changes in moisture content in fish during sterilization of preserves

Kind of fish	Loss in fish weight during stewing in %	Ratio of fish to juice during canning	Moisture content in fish in %		Moisture increase in % of moisture content in stewed fish		
			Before sterilization	After sterilization	Minimum	Maximum	Average
Carp	16.6	60:40	63.92	66.09	16.7	33.9	26.6
	18.7	60:40	59.71	66.48	28.1	33.1	30.6
	16.6	66:34	63.72	66.06	20.4	29.3	24.9
Bream	16.1	60:40	63.91	67.17	38.4	46.2	42.3
	16.1	66:34	62.04	68.75	37.9	48.7	43.3
Pike perch	16.4	60:40	71.25	69.29	13.8	23.0	19.1
	18.3	60:40	67.31	69.65	16.9	37.7	25.6
	16.6	66:34	71.56	69.43	18.9	22.4	20.7
Catfish	16.9	60:40	65.80	69.40	10.3	18.0	15.2
	19.9	60:40	58.63	68.27	26.9	36.5	31.5
	16.8	66:34	66.32	68.09	5.3	13.3	9.3
Sturgeon	19.1	66:34	63.14	64.48	10.5	19.6	15.0
	21.1	66:34	57.57	63.80	18.6	26.9	22.9
	21.6	74:26	56.16	65.60	—	—	13.2
Sevruga	19.9	66:34	60.44	64.96	10.4	28.0	19.3
	21.2	66:34	54.08	62.65	24.2	30.3	26.4
	20.7	74:26	56.69	62.83	—	—	19.4
White sturgeon	19.5	66:34	59.67	64.11	14.6	33.2	23.8
	21.7	66:34	55.29	61.79	18.6	24.5	22.4
	21.7	74:26	55.12	61.00	—	—	20.9

Thus, on increasing the extent of stewing of fish , the highest moisture absorption was observed in the case of catfish.

Increasing the canning norm of stewed fish during preparation of preserves of white sturgeon, sturgeon, and catfish helps to decrease the quantity of moisture absorbed by the fish from juice during sterilization, but has no influence on moisture increase in other kinds of fish.

It was not possible to determine the exact reasons for this, but we suppose that it was due to the differences in structure and physicochemical properties of muscle tissue in different kinds of fish. Possibly, more compact packing of fish, worsening the conditions of contact between fish and juice, may have had some effect.

The extent of moisture increase in fish in separate samples of preserves varied greatly. These variations and changes in moisture of fish during sterilization and stewing can be explained by the individual differences in every piece of fish (size, structure, composition).

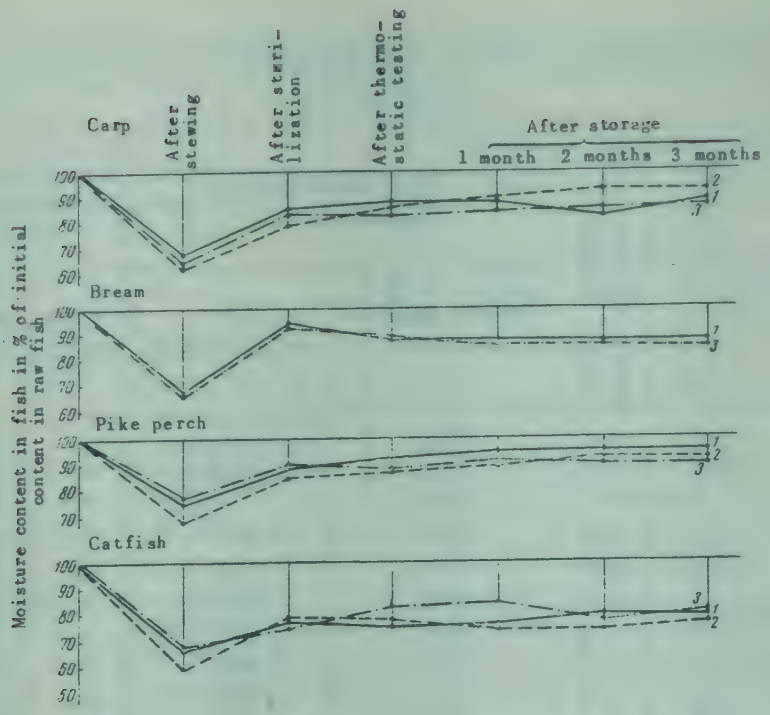

Figure 4. Changes in moisture content in Cyprinidae during the process of preparation and storage of preserves

1—Extent of stewing 16.1 - 16.9%, canning norm 60%;

2— " " " 18.3 - 19.9%, " " 60%;

3— " " " 16.1 - 16.8%, " " 66%.

The moisture content in fish of the Cyprinidae group after sterilization was 66 - 69.5%, and in Acipenseridae 62 - 65%, i.e., in every case it was less than the initial moisture content in fresh fish. Thus, the quantity of moisture lost by the fish during stewing is not fully restored during the sterilization of preserves. The appropriate calculations indicate that, by increasing the extent of stewing, the fish lost more moisture than it could recover from juice absorption during sterilization, despite the fact that the absorption capacity increases together with the increase in the degree of stewing (Table VIII). This apparent contradiction can be understood when we take into account that the moisture content of stewed fish is greatly decreased with the increase in the extent of stewing.

In our opinion, the moisture absorption from juice by fish during sterilization is brought about, not only by the swelling of the starch content in the crust, but also by the swelling of the fish meat itself through capillary absorption of water and hydration of proteins.

During the process of thermostatic incubation and storage of preserves only a small change in moisture content of fish takes place, in most cases showing a tendency towards increase.

During storage, the moisture content in fish of all kinds of preserves, with the exception of preserves prepared from catfish, considerably increases in fish stewed to a greater extent.

In Figures 4 and 5 are indicated the average moisture changes in fish, observed during the whole process of preparation and storage of preserves with the application of varied degrees of stewing and varied canning norms. Thus, in

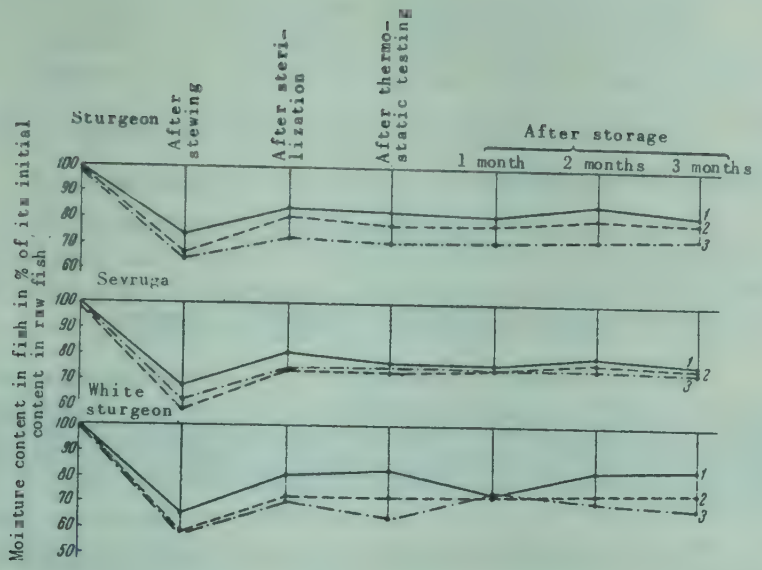

Figure 5. Changes in moisture content in Acipenseridae during the process of preparation and storage of preserves

1 – Extent of stewing 19.1 - 19.9%, canning norm 66%;

2 – " " " 20.1 - 20.7%, " " 66%;

3 – " " " 20.7 - 21.7%, " " 74%.

no case does the moisture content in preserved fish equal the initial moisture content of fresh fish.

CONCLUSIONS

1. The quantity of moisture lost by fish during stewing and before canning depends not only on the extent of stewing but also on the species of fish. With the same extent of stewing the greatest moisture loss in Acipenseridae was observed in sevruga, and in Cyprinidae in carp and catfish.

2. During sterilization of preserves there is usually a weight increase due to absorption of juice.

But in some cases, during preparation of preserves of very fat fish (sturgeon, catfish), a decrease in fish weight is possible due to the discharge of fish fat into the juice.

3. The quantity of juice absorbed by fish during sterilization of preserves depends on the type of fish and on the accepted ratio of fish to juice per can.

In the case of Cyprinidae fish under identical preserving conditions, the highest juice absorption was noted in bream and the lowest in catfish. Different Acipenseridae absorbed approximately the same amount of juice.

By increasing the canning norm of stewed fish, the relative quantity of absorbed juice decreased.

Increasing the extent of stewing of Cyprinidae from 16 - 17% to 19 - 20% had no effect on the absorption of juice, either in the case of fish having an average fat content or in lean fish (carp, pike perch), but considerably helped the increase of juice absorption by fat fish, especially catfish.

4. As a result of absorption of juice the moisture content during sterilization of preserved fish increased; but the amount of moisture lost by the fish during stewing was not fully recovered during sterilization. However, the fat Acipenseridae fish and catfish absorbed considerably less moisture than pike perch, carp, and bream.

By increasing the extent of stewing, the possibility of absorption of juice is reduced.

5. During the processes of thermostatic incubation and storage of preserves the moisture content in fish and, correspondingly, the relative weight of fish in preserves, show insignificant changes; most cases show a tendency towards a slight increase.

6. In order to obtain the required ratio of fish to juice in prepared preserves we suggest:

a) Calculating the loss of weight at 17,5% when stewing pike perch carp and bream; catfish and sturgeon at 20%.

b) Canning 209 g stewed pike pearch, carp, and bream (60%), 230 g catfish (66%), and 250 g Acipenseridae (71%) in size No 8 cans (net weight 350 g).

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QUANTITATIVE CHARACTERISTICS OF FISH AFTER SALTING

(K kolichestvennoi kharakteristike zakonchennykh posolov)

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The reactions of diffusions and osmosis which take place during fish salting are characterized by the transfer of water and salt to the fish-brine system. Normally the completion of the salting process is marked by the moment when there is a balance between the water and salt content of the fish tissue and the brine, and when a dynamic equilibrium—i.e., preservation of a constant distribution of water and salt in fish and brine — is achieved. The quantity of water transferred during the process of salting from the fish tissue into the brine is proportionate to the initial content of water in tissue and the final concentration of salt in the tissue sap and in brine. This interdependence is fully borne out in the practice of salting:

W = the initial water content of fish tissue (in %);
W_1 = the final water content of tissue (in % of fish weight before salting);
W_2 = quantity of water transferred from fish tissue to brine (in % of fish weight before salting);
c = the concentration of salt in tissue sap and brine at the end of salting (in %);
K_1 and K_2 = the proportionally coefficients.

Hence:

$$W_2 = K_1 Wc; \tag{1}$$

$$W_1 = W - W_2 = W - K_1 Wc = W(1 - K_1 c). \tag{2}$$

If the quantity of water transferred from the fish tissue to the brine is proportional to the salt concentration, it is clear that the quantity of water remaining in the tissue is inversely proportional to the salt concentration.

$$W_1 = \frac{W}{c} K_2. \tag{3}$$

Formulas (2) and (3) prove the well-established fact that when using the same doses of salt ("doses" of salt are defined as the equilibrium concentration in tissue sap and in brine at the end of salting) the more water remains in the tissues, the greater the initial water content.

Before beginning to verify the above-mentioned formulas relating to salting, we should like to remark on unsaturated salting.*

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* The article deals with rules applying only to normal salting with saturated/or near saturation point /salt concentration in brine at the beginning of salting, and with not less than 10% at the end.

In these saltings it is difficult to fix the exact water and salt contents of fish tissue at the moment of balancing of salt concentration in tissue sap and in brine. In a number of cases, before the balancing moment, we can note the brine absorption by the tissue, which is unconnected with the phenomenon of transference, which affects the dynamic equilibrium and changes the water ratio in tissue and in brine. This process affects the validity of the calculation, especially in those cases where the duration of salting is longer than usual.

In Table 1 are recorded the proportionality coefficients for Pacific Ocean herring and a number of other fish. With the exception of the above-mentioned statement the coefficient K_1 is not dependent on the quantity of salt and on the initial water content of fish tissue with the normal doses of salt used during salting.

The coefficient K_2, according to formulas (2) and (3), is dependent on c : $K_2 = c(1 - K_1 c)$, with the average of $K_1 = 0.017$ and of c from 15 to 25%, varying from 11.2 to 14.4. The stability of K_1 leads us to think that formulas (1), (2), and (3) are applicable for completed salting in all kinds of fish and with all methods of salting with the exception of salting by brine-trickling, as this method has a number of peculiarities.

The greatest variations from the probable values of the coefficient are obtained in those cases where fish were stored in salting vessels after completion of salting for a number of months and, simultaneously with the process of transference, the absorption of brine takes place. The accuracy of the calculations is also influenced by the homogeneity of samples subjected to analysis and also the precise determination of the water content of tissue at the beginning and at the end of salting, as well as of the balancing of salt concentration.

The average value of the coefficient calculated is not very precise because it is based only on limited material and in the future it should be carefully examined and verified.

It should be emphasized that the moment of completion of salting does not coincide with the moment when there is the lowest water content in fish tissue or, in other words, with the moment of the greatest transference of water from tissue to brine. Correcting the numerical values of the proportionality coefficients, we can use formulas (2) and (3) to calculate the lowest water content in tissue during the process of salting.

Formulas (2) and (3) enable us to detect other factors dependent on the initial water content of fish tissue and on balanced salt concentration at the end of the salting.

The concentration of salt in tissue sap is usually calculated by taking into account only water and salt, but, in fact, it contains a number of other substances, including organic ones. Nevertheless, because the tissue liquid is not analyzed, one may, for purpose of comparison, use the calculated concentration of salt.

In order to calculate the salt content of fish tissue at the end of salting, the following formula for calculation of salt concentration in tissue liquid was used:

$$c = \frac{S_1}{S_1 + W_1} 100 = \frac{S'_1}{S'_1 + W'_1} 100, \qquad (4)$$

S'_1 and W'_1 = salt and water concentration in fish tissue in percent of weight of salted fish, and S_1 and W_1 corresponding to fish weight before salting.

Table I

Kind of fish	Material investigated	Duration of salting in days	W	W_1^1	W_1	c	K_1	K_2	Sources of data
Don herring	Meat	60	68.80	46.63	40.10	24.20	0.0172	14.10	A.F.Shvetsov /5/
Pike perch	Meat	13	81.54	56.30	43.00	25.70	0.0182	13.55	"
Sprats	Whole fish	4	78.00	57.50	47.15*	23.30	0.0170	14.09	N.A.Semenov /3/
Kerch herring	Meat	30	66.15	48.70	42.80	20.80	0.0170	13.46	S.I.Gakichko /2/
White Sea herring	Meat	8	68.37	53.50	48.00	17.08	0.0167	12.50	"
Bream	Meat	21	77.50	53.90	43.20	25.00	0.0177	13.93	"
Caspian herring	Whole fish	175	69.50	49.00	42.60*	24.50	0.0158	15.03	M.I.Turpaev /4/
"	"	160	70.10	47.50	39.00*	25.30	0.0179	14.72	"
Bass	Meat	15	72.22	57.10	50.54	16.80	0.0178	11.75	L.A.Abashkina /1/
Cod	Fillet	23	83.04	63.76	55.10*	20.46	0.0164	13.58	Author's data
Pacific herring	Meat	—	70.80	56.57	50.35	17.34	0.0166	12.33	"
"	"	—	75.80	58.40	49.25	19.75	0.0174	12.82	"
"	"	—	72.00	49.30	40,46	25,10	0.0174	14.09	"
"	"	—	74.80	53.30	42.95	25.45	0.0164	14.59	"
Caspian sprats	Whole fish	3	69.80	53.77	47.00*	17.84	0.0183	12.02	P.A.Khar'kova **
"	"	3	69.30	50.40	43.55*	21.90	0.0174	13.77	" **

Average 0.017

By substitution of $W(1-K_1 c)$ for W_1, we obtain

$$c = \frac{100S_1}{S_1 + W(1-K_1 c)} \qquad (4a)$$

After slight transformations we obtain the following formula for calculation of S_1:

$$S_1 = \frac{cW(1-K_1 c)}{100 - c} \qquad (5)$$

From formula (5) we see that the larger the initial water content of tissue and the balanced concentration of salt at the end of salting, the greater the quantity of salt transferred.

The results of calculations according to formula (5) agree sufficiently well with the facts obtained by analysis of fish samples at the end of salting.

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* The water calculation from salted fish to weight of fresh fish was performed according to the formula $W_1 = \frac{W_1^1 g}{100}$, where g = output of salted fish. In the other cases the calculations were performed according to the formula $W_1 = W_1^1 \frac{t_1}{f_2}$, where f_1 and f_2 are the contents of compact organic remains in fresh and salted fish and W_1^1 = the water contents in percentage to salted fish. [apparently $w_1 = w_1^1 \frac{f^1}{f_2}$ was meant. Editor's Note.]

** The Manuscript Foundation of Azerbaijan Department of Caspiro.

The completion of salting is characterised by the dynamic equilibrium, by which the relative and absolute water and salt content of the fish tissue and brine remain at the same level. The constancy in water distribution enables us to define the interdependence between the initial and final water contents of fish tissue at the end of salting. It follows from formula (2) that,

$$\frac{W_1}{W} = 1 - K_1 c \qquad (6)$$

The interdependence expressed by formula (6) indicates that the relationship between the initial and final water contents of the tissue depended only on the equilibrium concentration of salt. On the average, the value of $K_1 = 0.017$; the ratio $W_1 : W$ (when the salt concentration (c) is from 10 to 25%) varied from 0.83 to 0.54.

By substituting for W in formula (6) its equivalent, the sum $W_1 + W_2$, and by making the necessary transformations, we obtained the following formula for distribution of water in fish tissue and brine:

$$\frac{W_1}{W_2} = \frac{1 - K_1 c}{K_1 c} \qquad (7)$$

Formula (7) indicated that the water distribution in the fish-brine system also depended on the value of the equilibrium concentration of salt. The larger the concentration, the less water remains in fish tissue and the greater the quantity of water transferred to the brine. With the same values of K_1 and c, which are accepted for calculation of $W_1 : W$, the ratio $W_1 : W_2$ varied from 4.9 to 1.2, which means that the major part of the water still remained in the fish tissue.

Now we turn to the definition of the dependence of loss in fish weight during salting on the initial water content and final salt concentration. Knowing the percentage of water and salt contents in fish tissue at the end of salting in relation to the weight of fresh fish and assuming that the quantity of organic substances remains constant (in short-term salting the loss of organic substances in relation to the weight of fresh fish does not exceed 0.5%), we can derive a formula analogous to that of M.I. Turpaev /4/ connecting the composition and weight of fish after salting:

$$W(1 - K_1 c) + \frac{Wc\,(1 - K_1 c)}{100 - c} + (100 - W) = 100 - q$$

After transformation we obtained the following formula for calculation of loss of fish weight q:

$$q = \frac{Wc(100\,K_1 - 1)}{100 - c} \qquad (8)$$

For calculation of loss, the following formula may be applied:

$$q = \frac{W(100c - 100\,K_2 - c^2)}{c(100 - c)} \qquad (9)$$

derived on the basis of formula (3).

Formulas (8) and (9) indicate that loss of fish weight at the end of salting is proportionate to the initial water content and to the equilibrium concentration of salt. We should note that at the end of salting the loss of weight is less than during the process of salting. This can be explained by the fact that the transfer of water

from tissue to brine is completed before the salting process, and the transference of salt continues up to the end of salting. In unsaturated salting the increase of weight at the end of salting is caused also by absorption of brine by the tissue. The frequent failure of identical types of fish salted under uniform conditions to undergo identical weight loss may be explained by the fact that the above-mentioned conditions were not taken into account. Even when calculating the loss of fish weight in saturated salting, we should take into account that a transference of water from brine into tissue took place in the last phase of salting, causing an increase in body weight through accumulation of salt. Therefore it is important when defining the loss to define precisely the state of salting and to establish the difference between the salt concentration in brine and in tissue sap.

The calculation of loss of weight according to formulas (8) or (9), as mentioned above, was carried out without taking into account the quantity of organic substances in fish weight, which can be dissolved in brine (up to 0.5% of fish weight or fish tissue before salting). The sum of these and other losses are an indication of what characterizes the changes in fish weight under influence only of salt concentration in brine and some salting conditions, e.g., temperature. Mechanical losses which take place during salting, e.g., dropping of scales, tearing of tissue, squeezing out of roe and tearing internal organs are not included in the formula. The technological losses took into account only the primary losses, which are the difference between water and organic substances transferred from fish tissue and salt absorbed by the tissue. The industrial losses combined the technological and mechanical losses , and were an indicator not only of the salting process but also of the state of the production process.

Substituting in formula (8) the corresponding numerical value for K_1 and K_2, and taking the average water content of Pacific Ocean herring as 70%, we found that on completion of salting, at the end of salt absorption, the technological losses in the basic group of salted herrings should be in the following range:

highly salted (c = from 20 to 25%) .. 12.2 - 16.3%
medium salted (c = from 15 to 20%) .. 8.7 - 12.2%
slightly salted (c = from 10 to 15 %) .. 5.4 - 8.7%

When the average water content is 75%, the quantity of technological losses correspondingly increases and is as follows, for:

highly salted ..... 13.1 - 17.5%
medium salted .... 9.2 - 13.1%
slightly salted .... 5.8 - 9.2%

Are these losses really technological ones? Our facts indicated that they are really similar to results obtained under experimental conditions, when the uncalculated mechanical losses are minimized and are generally caused by scales mixed with undissolved salt. Corresponding data for Pacific Ocean herring and other fish are noted in Table II.

We emphasize once more that formula (8) is valid for the last phase of salting. Dependent on an earlier or later termination of salting, as indicated in Table II, the value of the real technological losses will either increase or decrease. The above statement that the maximum of water transferred from tissue did not coincide with the completion of salting proves once more that interrupted salting is not always accompanied by a decrease in technological losses. During the beginning of salting we observed an increase in technological losses, of which the maximum was noted at the end of water transference. During further salting the technological losses decreased. So, even without taking into account the retransfer of water from brine to tissue, or the beginning of absorption of brine (by unsaturated salting), the continued diffusion of salt into fish tissue led to an increased salt

content in tissue, and consequently in the fish weight. The observations indicated that in saturated salting of Spring Pacific herring, the greatest losses occurred in the period when the salt content of fish tissue corresponded to the norm of medium-salted herring.

The application of formula (8) for the calculation of losses during salting is limited and results obtained were true only at the end of salting. And this is the cause of its insufficiency. The formula of M. I. Turpaev /4/ has a universal application, requiring a knowledge not only of the composition of raw material but also of the finished product. At the moment of completion of salting the technological losses calculated according to formula (8) and to that of M. I. Turpaev are the same.

On the basis of formula (8) we calculated the output of the finished product. In percent of fresh fish weight the output will be:

$$g = \frac{100(100 - c) - Wc(100K_1 - 1)}{100 - c} \qquad (10)$$

Table II

Kind of fish	W	c	W_1	S	Losses (q) estimated	Losses (q) actual
Pacific herring	70.80	17.34	56.57	10.60	10.4	13.6*
" "	75.80	19.75	58.37	13.26	13.0	13.6
" "	74.80	25.45	53.35	16.45	17.0	17.0
Cod (fillet)	83.04	20.46	63.76	16.42	14.9	13.5**
Sprattus (Clupea harengus membras)	78.00	23.10	57.50	17.20	16.4	16.8
Sprats	69.30	21.90	50.40	43.55	13.6	13.9

If we know the water and salt contents in tissue per weight of fresh fish (formulas 2 and 5) and also the output of the finished product, we can then establish the formula which would allow us to calculate the water and salt contents in proportion to the weight of salted fish.

$$W_1' = \frac{100W(1 - K_1c)(100 - c)}{100(100 - c) - Wc(100K_1 - 1)} \qquad (11)$$

$$S_1' = \frac{100cW(1 - K_1c)}{100(100 - c) - Wc(100K_1 - 1)} \qquad (12)$$

When establishing the numerical relationship which characterizes the finished salting, and especially the water transference from tissue to brine, we disregarded the effect of temperature. It is known that prolonged salting is dependent on the temperature. It should also be noted that an increase in temperature results in an increase in the quantity of water which is transferred from the tissue to the brine. The final water content of fish for the same salt concentration is less if the temperature of salting is higher.

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* Salting was interrupted before completion

** Salting was finished after completion

However, when transferring a great quantity of water from tissue to brine we need less salt to saturate the water remaining in tissue to the necessary equilibrium salt concentration, i.e., an increase in salting temperature leads to a decrease in the transference of salt to tissue.

The overall quantitative changes in water and salt transference are dependent on the temperature of salting. The effect of temperature on the transference process of water and salt is generally known, but it was not quantitatively evaluated and no corrections in temperature have been made. The problem of the near future is to find the temperature corrections and to introduce them in the formulas (1-12). From our facts we can form a preliminary conclusion that in the temperature range of 0-10°C the influence of temperature is not very great. The widespread use of refrigeration in the fish industry allows us, during the current five year plan, to replace the method of interrupted saturated salting by the preparation of slightly and medium-salted fish, by finished salting of a different degree of saturation. At the end of salting the finished salting will be characterized by the same concentration of salt in tissue, sap and in brine. The rules given for finished salting can be applied in the factories for production with previously planned quantitative indicators and for controlling the process of salting.

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THE COMPARATIVE CHARACTERISTICS OF ANCHOVY SALTING USING DRY SALT AND SALT SOLUTIONS

(Sravnitel'naya kharakteristika posola khamsy sukhoi sol'yu i v solevykh rastvorakh)

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In order to study the process of anchovy salting, we made a number of experimental saltings, using salt and solutions of different concentrations. In order to clarify the effect of temperature on the course of anchovy salting, the experiments were performed at different temperatures. During the salting process, we studied the changes in salinity and moisture of the fish, changes in their weight and size, and also the quality of the organoleptic state of the fish. During the salting of anchovy using dry salt, the amount of brine which appeared was also controlled.

In every case the experimental salting of the anchovy lasted for 10 days, at the end of this time the absorption of salt came to an end and had practically reached the equilibrium state.

In order to receive a full and comparable picture of the salting process, including changes in body weight, size, and salt absorption samples of the fish were taken for analysis and study after different time intervals. These were more frequent at the beginning of the salting process. Because the quality and chemical contents of unsalted fish may have a considerable influence on the changes taking place during salting, special attention was paid to the selection of fish used for experimental purposes.

Fresh anchovy of a very large uniform size were used throughout. Comparison of salting, using dry salt and salt solutions, was based on the following four criteria:

1. The rate of salt penetration into the fish
2. Loss of moisture by the fish
3. Loss of dense substances by the fish
4. Output quantity and quality of finished, salted fish

At the end of our experiments the optimum salting method was chosen on the basis of these criteria.

Rate of Salt Penetration into the Fish

By rate of salt penetration into the fish, or rate of salting, we mean the quantity of salt absorbed by the fish within a given time. The problem of the rate of salt penetration with different methods of salting has not been sufficiently studied, and the opinions of different authors vary.

Nevtonov /8/, studying the dynamics of salting Kerch herring, noted that with the same salting time, herrings salted with dry salt have less salinity than those salted in saturated brine. According to his results, the percentage of salinity in herrings on the 3rd day of salting in brine was 17.3 %, on the 9th day 18.6 %, and on the 26th 18.8 %. With the same time intervals, the salinity of herrings salted

with dry salt were 11.3%, 15.9% and 17.4%. Thus, according to Nevtonov, salting with brine acts more quickly than salting with dry salt.

Borisov*, Berezin /1/, and Terent'ev /11/, are of the same opinion concerning salting in circulating brine. However, Dragunov and Kasinova /3/, Voskresenskii/2/ and Minder /5/ did not find any considerable acceleration of salt penetration when using brine. Voskresenskii noted, in particular, that the average rate of salting sardines in circulating brine was only 1.12 times faster than the average rate of salting with dry salt, and 1.35 times faster than salting in stationary brine.

Some acceleration of the salt absorption in fish during salting in circulating brine, in comparison with salting in stationary brine and with dry salt, can be explained by the faster removal of the brine which was distilled near the surface of the body of the fish.

The question of the dependence of salt absorption on the measure and method of salting, (e.g., on the amount of salt used in dry salting), was investigated in detail in the papers of Semenov /9/ and Voskresenskii /2/. But their results are not comparable to our results because our experimental methods were different.

In our investigation, in order to define the rate of salting, we calculated the average rate of salt penetration into the fish during the salting period by using the following formula:

$$v_{cp} = \frac{c_2 - c_1}{t} \qquad (1)$$

V_{av} = the average rate of salt entrance into the fish in kg per hour,

C_1 = the quantity of salt (in kg) contained in the fish at the beginning of the salting period;

C_2 = the quantity of salt (in kg) contained in the fish at the end of the salting period;

t = the salting time in hours.

In our calculations of the quantity of salt penetrating the fish within a given time, we took into account the weight changes of the fish during the salting, and all calculations were made accordingly for a batch of 100 kg of unsalted fish.

The results of our calculations of the rate of penetration of salt into anchovy during different periods of salting using different methods, are recorded in Tables I and II.

According to these tables, during salting with dry salt and salt solutions the salt penetration into the fish was greatest in the first 3 hours. During this time, an average of approx. 30 % of all the salt found in the fish at the end of the salting (after 10 days) entered the anchovy. The rate of the salt penetration then sharply decreased and, during the periods from the 3rd - 6th, and 18th - 24 hours, was less than in the initial period (0 - 3 hrs). In various cases it was 3 - 6 times less. During the period of 24 – 48 hrs, the rate of salt absorption became even slower, and on the average was 20 – 40 times less than in the first 3 hours.

After 24 hours the quantity of salt in the anchovy, using the dry salting method was 65 - 70 %; with salting in saturated and in 20 % solutions, up to 85 - 90 % of the whole quantity of salt was absorbed into the fish by the end of the salting period.

The rate of salt penetration differed considerably in the initial stages of the salting, depending on the amount of dry salt or on the concentration of salt solution, but after the initial stages the differences disappeared.

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* Borisov: The mechanization of the salting process of fish, TINRO, 1939.

Table I

The speed of salt penetration into the fish (in kg per hr) during salting of anchovy in brine of different concentrations and at different temperatures (calculations based on 100 kg of fresh fish)

Periods of salting	Salting at + 17°				Salting at + 6°				Salting at − 2°			
	Salt concentration in brine, in %											
	10	15	20	condensed	10	15	20	condensed	10	15	20	condensed
0—3 hours	0.558	0.918	1.65	1.291	0.526	0.920	1.164	1.322	0.761	0.822	1.075	1.269
3—6 "	0.210	0.149	0.276	0.181	0.172	0.152	0.282	0.089	0.006	0.155	0.279	0.083
6—12 "	0.207	0.413	0.478	0.529	0.177	0.416	0.486	0.571	0.265	0.482	0.491	0.059
12—18 "	0.027	0.183	1.157	0.244	0.138	0.176	0.177	0.208	0.054	0.156	0.180	0.211
18—24 days	0.128	0.089	0.108	0.087	0.043	0.099	0.081	0.087	0.117	0.034	0.051	0.079
1—2 "	0.023	0.020	0.007	0.031	0.028	0.020	0.006	0.031	0.032	0.017	0.008	0.030
2—5 "	0.020	0.050	0.017	0.014	0.006	0.005	0.007	0.014	0.016	0.005	0.003	0.002

Table II

The speed of salt penetration into the fish in kg per hr with different dry salt dosages and at different temperatures.

(calculations based on 100 kg of fresh fish)

Periods of Salting	Salting at + 12°C				Salting at − 2°C			
	Salt dosage in %							
	12	15	20	25	12	15	20	25
0—3 hours	0.811	0.678	1.006	1.148	0.844	0.912	0.972	1.230
3—6 "	0.450	0.841	0.754	0.909	0.317	0.544	0.580	0.346
6—12 "	0.119	0.191	0.067	0.047	0.106	0.189	0.154	0.191
12—18 "	0.050	0.132	0.146	0.209	0.118	0.138	0.197	0.177
18-24 "	0.171	0.142	0.054	0.212	0.167	0.088	0.125	0.119
1—2 days	0.033	0.046	0.089	0.056	0.022	0.042	0.024	0.044
2-5 "	0.017	0.023	0.032	0.027	0.014	0.024	0.012	0.016
5—10 "	0.012	0.008	0.006	0.003	0.012	0.012	0.008	0.011

During anchovy salting with salt solutions, the average rate of salt penetration in the initial period (i.e., in the first 3 hours.), when using saturated and 20 % solutions was 2 - 2.5 times greater, and when using a 15 % solution 1.5 times greater than in the case of using a 10 % solution.

When salting with dry salt, the average rate of salt penetration during the first 3 hours, using salt dosages of 20 % and 25 %, was 1.2 - 1.3 times greater than with dosages of 12 % and 15 %.

Temperature during salting remained within the range of minus 2 to plus 12 – 17°C, and had no great influence on the rate of salt penetration.

In order to compare salt penetration rates during salting with dry salt and with salt solutions, we recorded in Table III all results obtained in our experiments, except for those of salting the anchovy in 10 % and 15 % salt solutions, because they were not used in practice.

Table III

Average speed of salt absorption in kg per hr in anchovy when different salting methods are applied.

(calculations based on 100 kg of fresh fish)

Periods of salting	Salting in brines		Salting with dry salt	
	20 % solution	saturated	12 – 15 % solution	20 – 25 % solution
0–3 hours	1.075–1.165	1.269–1.322	0.678–0.912	0.972–1.230
3–6 "	0.276–0.282	0.099–0.181	0.317–0.841	0.346–0.909
6–12 "	0.416–0.491	0.529–0.571	0.106–0.191	0.047–0.191
12–18 "	0.157–0.180	0.208–0.244	0.050–0.138	0.146–0.209
18–24 "	0.051–0.108	0.079–0.807	0.088–0.171	0.119–0.212
1–2 days	0.006–0.008	0.030–0.031	0.022–0.046	0.024–0.089
2–5 "	0.003–0.017	0.002–0.014	0.014–0.024	0.012–0.032
5–10 "	0.002–0.004	0.001–0.008	0.008–0.012	0.003–0.011

According to Table III we see that, in the initial period of salting, the rate of salt penetration into the anchovy salted in 20 % and in saturated solution was in every case higher than in dry salting, even with the use of large dosages (20 – 25 % of salt). If we take as a unit the rate of salt penetration with dry salt, using dosages of 12 - 15 %, then, in relation to this figure, the rate of salt penetration using dry salt with dosages of 20 - 25 % and salting in a 20 % salt solution was 1.2 – 1.3, and in salting with saturated salt solutions 1.5 – 1.6.

Correspondingly, the relation of salt penetration when salting in saturated salt solutions to the salt penetration rate using dry salt with a salt dosage of 20 - 25 %, was approx. 1.2, which is very close to the coefficient of salting acceleration in brine salting of sardines, found by Voskresenskii /2/. However, during the salting period from the 3rd to the 6th hour, the rate of salt penetration, in all cases where salt solutions were used (according to Table III), was less than when salting with dry salt. But in the 6th - 12th hr period, the speed was considerably greater. Furthermore, beginning from the 12th hr up to the end of the salting period (after 10 days) no marked difference was observed in the rate of salt penetration into the anchovy. The nature of the rate changes of the salt penetration into the anchovy corresponded to the nature of the loss of moisture during the salting process.

In salting with dry salt, the quantity of water extracted increased gradually during the whole salting process. When salting with salt solutions, in the 3rd-6th hr

period, slowing down of the moisture extraction process was observed.

Hence, according to our results, in anchovy salting in salt solutions, salt absorption seemed to have stopped for a short time soon after the commencement of salting (between the 3rd and 6th hour). The cause of this phenomenon is not completely clear. It is possible that it was caused by a short-lived, strong freshening of the layer of brine near the fish, as a result of very intensive salt absorption during the time preceding it.

On the whole, we may conclude that from the point of view of absorption, the salting of anchovy in saturated salt solutions has an advantage over salting in a 20 % salt solution, and also over salting with dry salt using a dosage of 20 - 25 %. In the latter two cases, the salt absorption rates of the anchovy were very similar.

Moisture Losses of the Fish

In the analysis of the moisture changes in the anchovy during the salting period, we calculated these losses during various salting times, using the following formula:

$$Q = \frac{A_1 W_1 - A_2 W_2}{A_1 W_1} \cdot 100, \qquad (57a)$$

where:

Q = the moisture losses of the fish as a percent of the moisture content of fresh unsalted fish;
A_1 = the weight of the fresh fish before salting;
A_2 = the weight of the fish after a specific salting time;
W_1 = the moisture in the fish before salting per cent ;
W_2 = the moisture in the fish after a specific salting time in percent.

Results of the moisture losses of anchovy during different stages of salting with salt solutions and with dry salt are recorded in Tables IV, V, VI and VII.

Table IV

Changes in moisture content (as a % of body weight) during salting of anchovy in brines. (Initial moisture content 60.6 %)

Time from beginning of salting	Salting at + 17°C				Salting at + 6°C				Salting at − 2°C			
	Salt concentration in %											
	10	15	20	saturated	10	15	20	saturated	10	15	20	saturated
3 hours	60.0	59.7	57.7	57.1	58.9	59.0	57.9	57.2	58.4	58.1	58.1	57.0
6 "	59.3	58.5	56.2	56.6	58.1	58.4	57.0	56.3	57.6	57.7	57.2	56.7
12 "	58.4	55.1	53.2	53.5	56.7	55.0	54.1	53.3	55.9	55.2	54.2	53.5
18 "	60.1	54.0	51.4	51.5	56.3	54.3	51.1	51.5	54.5	53.8	51.4	51.6
24 "	60.8	53.3	51.0	50,8	55.5	53.5	51.2	50.8	54.2	53.1	51.0	50.5
2 days	59.7	52.8	50.3	48.9	56.2	52.6	50.8	49.3	54.3	52.4	50.7	49.1
5 "	59.2	52.5	49.3	47.5	57.1	52.1	49.6	48.4	55.3	52.0	50.3	48.3
10 "	58.3	52.1	48.6	46.5	57.2	52.8	48.6	46.5	55.5	51.4	49.9	48.7

The amount of moisture extracted from the anchovy at the end of the experiments (after 10 days) varied with :

1) the concentration of the salt solutions or the salt dosages, and
2) the temperature.

According to Tables VIII and IX, if the dosage of dry salt or the concentration of the salt solution was greater, so also were the moisture losses at the end of salting. In all cases of salting with dry salt, and also when salting in 20 % and in saturated solutions, increasing the temperature helped to increase the quantity of moisture extracted. Using a 15 % salt solution, the increase in temperature during salting had almost no effect on the amount of moisture extracted, and, when using a 10 % solution, it was accompanied by a decrease in the quantity of moisture extracted from the fish.

Table V

Moisture loss (as a % of the initial moisture content of the fish) during anchovy salting in brine. (Initial moisture content 60.6 %)

Time from beginning of salting	Salting at + 17°C				Salting at + 6°C				Salting at − 2°C			
	Brine concentration in %											
	10	15	20	saturated	10	15	20	saturated	10	15	20	saturated
3 hours	1.6	2.4	7.6	9.1	4.5	4.2	7.1	8.2	5.8	6.5	6.6	9.3
6 "	3.4	5.5	11.4	10.4	6.5	5.7	9.4	11.1	7.9	7.6	8.8	10.2
12 "	8.2	14.1	17.3	18.0	10.1	14.3	16.6	18.5	12.1	12.9	16.3	18.0
18 "	1.4	16.8	23.0	23.5	11.1	17.7	23.3	22.8	15.6	17.3	23.0	22.6
24 "	5.3	18.5	24.0	24.4	13.1	18.0	23.5	24.4	16.3	19.0	23.9	25.3
2 days	2.4	19.2	25.6	29.0	11.3	20.2	24.4	27.9	16.1	20.7	24.6	28.3
5 "	3.7	20.4	27.9	31.9	9.1	21.3	27.2	29.9	13.6	21.6	25.6	30.1
10 "	6.1	21.4	29.3	34.8	8.8	19.7	29.5	33.0	13.1	23.0	26.5	29.2

The results given in Tables VIII and IX, concerning the amount of moisture extracted from the anchovy at the end of the salting period, being dependent on the dry salt dosage, concentration of salt solution, and temperature, do not exactly reflect the nature of the moisture changes in the anchovy under the different salting conditions. However, the detailed results of all the observations recorded in Tables IV–VII indicate that in all cases of salting with dry salt, and except for salting in a 10 % solution, extraction of moisture from the fish takes place during the whole process.

In the salting with a 10 % solution, the difference in comparison with all the other experiments was that we observed not only loss of moisture from the fish, but also the introduction of moisture into the fish (swelling).

The swelling of the fish after salting with a 10 % salt solution began at different times, depending on the temperature. At − 2° and + 6°, the maximum moisture loss of the fish (13.1 and 16.3 %) was marked after one day, and then a gradual process of water absorption began, continuing until the end of the experiment. At + 17° the moisture loss reached its maximum (8.2 %), and 12 hours later, during the 12th - 24th hour period, moisture penetration into the fish was observed, and the moisture content exceeded the initial figure by 5.3 %. Towards the end of the salting, a small decrease in the moisture content took place.

Table VI

Moisture changes in anchovy, (as a % of its body weight), during salting in dry salt. (Initial moisture content 63.2%)

Time from beginning of salting	Salting at + 12°				Salting at − 2°			
	Dosage of salt in %							
	12	15	20	25	12	15	20	25
3 hours	62.0	61.1	60.4	61.3	61.6	61.0	60.8	60.6
6 "	60.1	59.1	58.9	53.6	59.9	60.2	59.5	59.3
12 "	58.9	58.7	56.7	56.6	58.9	59.7	58.9	58.5
18 "	57.6	58.0	55.9	55.7	57.7	58.4	57.0	57.1
24 "	57.1	56.8	53.5	58.2	57.3	57.7	56.1	56.3
2 days	55.4	54.2	50.8	50.4	56.4	55.8	55.3	55.4
5 "	53.5	51.7	49.1	47.2	55.9	54.4	53.1	52.7
10 "	52.2	50.3	48.4	46.1	54.6	53.1	50.4	50.6

Table VII

Moisture loss (as a % of the initial moisture content of the fish) during salting anchovy in dry salt. (Initial moisture content 63.2%)

Time from beginning of salting	Salting at + 12°				Salting at − 2°			
	Dosage of salt in %							
	12	15	20	25	12	15	20	25
3 hours	3.1	5.4	7.1	4.9	4.0	5.6	10.0	6.6
6 "	7.8	10.3	10.8	11.6	8.4	7.6	9.4	9.8
12 "	11.8	12.9	16.0	16.4	9.2	9.3	10.8	10.9
18 "	13.8	13.0	18.0	16.7	13.8	12.5	15.4	15.2
24 "	15.2	15.9	23.6	24.2	14.7	14.3	17.6	17.1
2 days	19.2	22.0	29.6	30.0	16.8	18.3	19.9	19.4
5 "	23.6	27.6	33.3	37.0	18.0	21.6	24.5	25.4
10 "	26.5	30.7	34.8	39.5	21.0	24.5	30.5	31.7

We may assume that the above-mentioned specific nature of the moisture changes in anchovy when salting in a 10 % solution was in some way connected with the cases of fish spoilage observed during the salting period.

Table X compares the moisture losses of the anchovy during different salting times with salt solutions and with dry salt at the temperature range of 6 – 17°C.

According to Table X, during the first few days the moisture elimination from the anchovy when salting in a 20 % solution and with saturated solutions was more intensive than when salting with dry salt. After 18 hours of salting with the above-mentioned salt solutions, the anchovy lost an average of 23 % of moisture, and when salting with a dosage of 20 - 25 % dry salt the same moisture loss was observed only after 24 hours.

Thus, the rate of moisture extraction when salting in salt solutions was approx. 1.3 times larger than when using dry salt.

But in the salting time that followed, i.e., from 1 - 10 days, the moisture extraction was more intensive when salting with dry salt than when salting in salt solutions.

Table VIII

Moisture loss of anchovy after 10 days of salting in solutions of different concentrations

Concentration of salt in brine in %	Loss of water (in % from its initial content in fresh fish) during the salting process at the temperature of :		
	+ 17°	+ 6°	– 2°
10	6.1	8.8	13.1
15	21.4	19.7	23.0
20	29.5	29.5	26.5
saturated solution	34.8	33.0	29.2

Table IX

Moisture loss of anchovy after 10 days of salting in dry salt, depending on salt dosage and temperature

Dosage of salt in %	Loss of water (in % from its initial content in fresh fish) during the salting process at the temperature of :	
	+ 12°	–2°
12	26.5	21.0
15	30.7	24.5
20	34.8	30.5
25	39.5	31.7

Table X

Moisture loss of anchovy during the processes of salting with dry salt and in brine

Time from beginning of salting	Moisture losses in % from the initial content in fresh fish			
	Salting in brine		Salting with dry salt	
	20 % solution	saturated solution	12-15 % salt	20-25 % salt
3 hours	7.1–7.6	8.2–9.1	3.1–5.4	4.1–7.9
6 "	9.4–11.4	10.4–11.1	7.8–10.3	10.8–11.6
12 "	16.6–17.3	18.0–18.5	11.8–12.9	16.0–14.4
18 "	23.0–23.3	22.8–23.5	13.0–13.8	16.7–18.0
24 "	23.5–24.0	24.4–25.3	15.2–15.9	23.6–24.2
2 days	24.4–25.6	27.9–29.0	19.2–22.0	29.2–30.0
5 "	27.2–27.9	29.9–31.9	23.6–27.6	33.0–37.0
10 "	29.3–29.5	33.0–34.8	26.5–30.7	34.8–39.5

Loss of Compact Substances by the Fish

The compact substances of the fish is the conventional name for the mass of nitrogen, fat, and mineral substances in the fish, with the exception of natrium chloride. It is well known that in fish salting, a part of the nitrogen and fat substances soluble in salt solutions, are eliminated together with the moisture. The mineral substances are mainly found in the bones and, therefore, we may suppose that their quantity did not change during salting. The question of nitrogen and fat losses is of considerable practical importance, but has not been sufficiently investigated.

Kleimenov /4/ found that during the salting of Don herrings in saturated salt solutions, the loss of organic substances (protein and fat), after 7 days of salting, was 5.5 %, and after 8 days, 2.3 %. During the salting of the same fish in a 16.5 % solution, the loss of compact substances was 6.7 and 4.3 %, and when salting in a 13.2 % solution, 3.4 and 4.7 %. The data obtained by Kleimenov are contradictory and he did not find any connection between losses of compact substances, the concentration of the salt solution, and the duration of the salting process.

Sukrutov /10/ found that top quality bream lost less compact substances during salting than bream of an inferior quality, and explained the fact by changes which take place within the inferior fish before salting.

Minder /7/ noted that the degree of loss of compact substances depended on the temperature at which the salting process was performed. According to his findings, in the case of anchovy salting in salt solutions at a temperature of 0°, the loss of compact substances is considerably greater than at a temperature of $20 - 25^{\circ}$; but with an increase in salt concentration the difference disappeared. We should like to emphasize that in separate experimental saltings at a temperature of $10 - 12^{\circ}$, Minder found that in comparison to salting at 0°, in some cases there were more losses, and in other cases, less.

Dragunov * made experiments on bream, and observed that more nitrogenous substances are extracted from the fish during cold than during warm salting.

The experiments performed by the Research Board of Canada /13/ concerning the solubility of fish meat protein (cod, halibut and Gadus aeglefinus) in salt solutions of different concentrations and at different temperatures, lead us to believe that the largest quantity of proteins would be lost in cold salting and in weak salt concentrations.

In our experiments we tried to establish the size of the loss of compact substances in anchovy and its dependence on the salting method.

The amount of compact substances in fresh and salted anchovy was calculated by the following formula:

$$x = 100 - (A+B),$$

where x = % contents of compact substances in fish;

A = moisture of fish in %;

B = salinity of fish in %.

In calculating the compact substances, we took the salinity of fresh fish as equaling 0. Basing our calculations on content of compact substances in the fish, found together with data of weight changes during salting, we calculated the loss of compact substances by the formula:

$$x = \frac{A - \frac{BC}{100}}{A}$$

where x = the % loss of compact substances in fresh fish;

A = the % contents of compact substances in fresh fish;

B = the % contents of compact substances in salted fish;

C = the weight of the salted fish as a % of the weight of the fresh fish.

The results of our calculations of the compact substances content of the fish and their losses after various salting times obtained with our methods of salting anchovy are given in Tables XI, XII, XIII and XIV.

The results indicate that the relative amount of compact substances in salted anchovy was in every case lower than in the fresh fish. Fresh anchovy taken for experimental saltings in salt solutions contained 39.4 % of compact substances, and those taken for salting in dry salt 36.8%. At the end of the salting period (after 10 days), the anchovy in the salt solutions contained 35.9 - 38.5 % compact substances, while those in the dry salt contained 29.9 - 34.1 %.

Thus, the loss of compact substances during salting with dry salt was greater than when using salt solutions. After 24 hours, the anchovy salted by the dry salt method (dosage of 12 - 25 %), lost 6 - 15.8 % of all the compact substances contained in the fresh fish. After 2 days the loss was 10.8 — 17.1%, and after 10 days 12.5 - 18.6 %. In anchovy salted in salt solutions (concentrations from 15 % to saturation) the losses of compact substances were accordingly 4.2 - 11.5 %, 5.4 - 8.9 % and 2.3 - 8.9 %.

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* The prospects of the rational utilization of the sardine and anchovy. The Azov Department of VNIRO 1935.

Table XI

Changes in content of compact substances in anchovy (as a % of its body weight) during salting in brine . (Initial content of compact substances 39.4 %

Time from beginning of salting	Salting at + 17°C			Salting at + 6°C			Salting at −2°C		
	Salt concentration in brine in %								
	15	20	saturated	15	20	saturated	15	20	saturated
3 hours	36.9	37.6	37.7	37.0	37.4	37.3	38.8	37.7	38.2
6 "	37.2	37.8	37.3	37.5	37.2	37.8	38.4	37.3	37.8
12 "	36.9	35.4	35.5	36.8	35.6	35.4	37.0	35.8	36.1
18 "	36.8	35.1	35.8	36.9	35.6	34.7	38.0	36.0	35.9
24 "	37.1	35.6	34.9	37.2	35.7	35.2	37.8	36.2	35.6
2 days	36.8	36.5	36.3	37.2	36.2	35.9	36.7	36.5	36.6
5 "	36.4	37.2	36.6	37.2	37.1	36.1	37.5	36.7	37.5
10 "	36.1	37.6	37.0	38.9	38.5	37.6	—	—	—

Table XII

Loss of compact substances in anchovy (as a % of its initial content) during salting in brine.

(Initial content of compact substances 39.4 %)

Time from beginning of salting	Salting at + 17°			Salting at + 6°			Salting at −2°		
	Salt concentration in brine in %								
	15	20	saturated	15	20	saturated	15	20	saturated
3 hours	6.4	4.6	4.5	6.5	5.0	5.4	4.0	4.3	3.2
6 "	5.7	4.2	5.5	4.8	5.6	4.1	2.5	5.4	4.0
12 "	6.4	10.2	9.9	6.8	9.6	10.1	6.2	9.2	8.5
18 "	6.1	10.5	4.9	6.5	9.6	11.9	6.4	8.5	9.4
24 "	5.9	9.7	11.5	5.5	9.4	10.7	4.2	8.1	9.7
2 days	6.5	7.4	7.8	5.4	8.2	8.9	6.8	7.4	7.3
5 "	7.5	5.6	7.2	5.6	5.7	8.4	4.8	6.9	4.9
10 "	8.4	4.5	6.1	8.9	2.3	4.4	—	—	—

Table XIII

Changes in content of compact substances in anchovy (in % of its body weight) during salting with dry salt .

(Initial content of compact substances 36.8 %)

Time from beginning of salting	Salting at 12°				Salting at −2°			
	Dosage of salt in %							
	12	15	20	25	12	15	20	25
3 hours	34.5	35.7	34,3	33,9	35.0	35,4	35,2	31,6
6 "	34.9	34.3	33.3	32,7	34.7	34,3	34,9	34,6
12 "	34.0	32.9	33.9	33,2	34.6	32,3	32,6	32,8
18 "	34,3	31.6	32.7	32,4	33,9	32,5	32,5	32.0
24 "	34.4	30.9	31,6	31,1	33,3	32,0	32,2	31,6
2 days	32.7	31.0	32,8	32.1	32,9	32,3	30,4	30,5
5 "	33.0	31.0	31.8	30.9	32,0	31,8	30,9	23,9
10 "	32.2	30,3	30,9	30,9	31,3	34,1	32,0	29,9

Table XIV

Loss of compact substances in anchovy (in % of its moisture content) during salting in brine.

(Initial content of compact substances 36.8 %)

Time from beginning of salting	Salting at + 12°				Salting at −2°			
	Dosage of salt in %							
	12	15	20	25	12	15	20	25
3 hours	6.0	3.3	6.8	7.9	5,0	4.0	4.5	6.2
6 "	5.2	7.0	9.6	11.3	5.8	6.0	5.2	6.2
12 "	7.5	10.7	8.0	9.8	6,1	11.6	11.7	10.9
18 "	7.1	11.8	10,2	12.1	6.6	12.3	11,9	12.6
24 "	6.9	13.5	14.3	15.8	6.0	13,2	12.6	14.3
2 days	11.3	15.7	11.0	13.0	10.8	12,1	17.3	17.1
5 "	11.9	10.6	12.7	16.6	13.2	13.7	16.1	18.7
10 "	12.5	17.9	16.3	16.2	16.1	7.4	16.3	18.6

Thus, when salting with dry salt the loss of compact substances increased on prolongation of salting time, but in salting with salt solutions we did not observe any such connection. Like other authors (Kleimenov, Minder), we also observed in these cases an initial increase, followed by a decrease, in the amount of compact substances lost upon prolongation of salting. The cause of this phenomenon is not clear and should, in the future, be investigated in detail.

In some cases, on calculation of the loss of compact substances, we obtained results which varied, but the results generally obtained allow us to reach certain conclusions concerning the effect of the methods of salting on the loss of body weight of the fish.

According to our results, when salting anchovy in dry salt the loss of compact substances increased a little with the increase of the salt dosage, and with a decrease in temperature during the salting. When salting in salt solutions, there appeared a tendency for the loss of compact substances to increase with each increase of salt concentration in the solution, as well as with any increase in temperature.

The results of our observations concerning the loss of compact substances in the anchovy during salting in salt solutions do not agree with those obtained by the Canadian researchers, concerning the influence of salt concentration in solution and temperature on protein extraction from fish meat. This can be explained by the fact that we experimented with fatty, and not with lean, fish, and that we calculated not only the myosin extraction, but the total loss of compact substances, (i.e., all the nitrogenous substances together with the fat).

It is interesting to compare the loss of compact substances in anchovy salted by various methods, during the period when the fish have already reached some degree of salinity. Appropriate results are given in Table XV.

Thus, in cases of salting anchovy in a 20 % solution and in saturated solutions, when the salinity of the fish reaches the limits of slight and medium salting (7 - 11%), the loss of compact substances was on the average 8 - 10%. Upon salting anchovy with dry salt, the fish had reached the same degree of salinity, the amount of compact substances was greater than when salting in salt solutions – on the average 11 - 14 %; in some specific cases it reached 17%. During the preparation of a highly salted anchovy (salinity 14 - 15 %), using the dry salting method, the loss of compact substances reached 16 - 18 %.

We may therefore conclude that, from the point of view of the preservation of the nourishing substances in the anchovy, salting in salt solutions has an advantage over using dry salt.

The Output and Quality of Salted Anchovy

According to our observations concerning the changes in anchovy salinity during salting, we established the necessary salting data for preparation of slightly medium, and highly salted products under various conditions. According to our observations on weight changes during salting, we established the possible anchovy output for different degrees of salinity when salting with dry salt and in salt solutions.

The corresponding data are given in Table XVI.

According to this data, the output of slightly and medium-salted anchovy, when salting in salt solutions with and without cooling, was similar, and in the region of 90 - 93 %.

Table XV

Loss of compact substances in anchovy (in % of the initial content of fresh fish) with varying degrees of salinity, depending on the salting method.

Anchovy	Salinity of fish in %	Salting in brines					
		With cooling			without cooling		
		Concentration in brine in %					
		15	20	saturated	15	20	saturated
Slightly salted	7–8	5.5–6.5	8.5–9.0	7.0–9.0	5.5–6.5	9.5–10.5	8.0–11.0
Medium salted	9–11	—	7.5–8.0	8.5–9.5	—	7.5–9.5	10.0–12.0
Highly salted	14–15	—	—	—	—	—	—

Table XV
(continued)

Anchovy	Salinity of fish in %	Salting with dry salt							
		With cooling				without cooling			
		Dosage of salt							
		12	15	20	25	12	15	20	25
Slightly salted	7–8	11.0–11.5	12.0–13.0	12.0	11.5–12.0	11.0–11.5	11.5–13.5	9.5–11.5	10.5–11.5
Medium salted	9–11	—	12.5–13.0	17.0–17.5	14.5–17.0	—	12.0–14.0	11.0–11.5	13.0–15.5
Highly salted	14–15	—	—	—	18.0–18.5	—	—	—	16.0–16.5

Table XVI

Anchovy output with different degrees of salinity (in % of the weight of the fresh fish) during salting in dry salt and in brine.

Kind of product	Salinity	Salting in brine				Salting with dry salt							
		with cooling		without cooling		with cooling				without cooling			
		salt concentration in brine in %				salt dosage in %							
		20	saturated	20	saturated	12	15	20	25	12	15	20	25
Anchovy – Slightly salted	7–8	92–93,5	93–95	89,5–93	91,0–93,5	89,5–90,0	92–93	90,5–92	92–93	88–88,5	88,5–90,0	87–88,5	89–89,5
Anchovy – medium salted	9–11	91–91,5	91–92	90,5–91,5	90–91	–	89,5–90,0	85–87	88–90	–	85–86	84–85	85–87
Anchovy – highly salted	14–15	–	–	–	–	–	–	–	84–85	–	–	–	81–82

Approximately the same output was reached for slightly salted anchovy when salting with dry salt and cooling. The output of medium-salted anchovy, when using the dry salt method with cooling, was 3 – 5% less than when salting in salt solutions and reached 85 – 90%.

Salting with dry salt without cooling caused the output of the salted anchovy to be the lowest in every case. For slightly salted anchovy, it reached 87 - 90 %, for medium-salted, 84 - 87 %, and for highly salted, 81 - 82 %.

This lower output when salting with dry salt, as compared with salting in salt solutions, can be explained by the loss of compact substances, especially without cooling, and by the more intensive extraction of moisture when salting with dry salt.

In order to calculate the possible output of salted fish, it is often advisable to make a calculation using data on the chemical composition, and especially by the data concerning moisture and salinity. For such calculations, the formula proposed by Turpaev /12/ is usually employed.

$$P = \frac{100/(H+S) - (H'+S')}{100 - (H'+S')}$$

where P = The loss of fish weight during salting;

H = The moisture content of fresh fish in %;

H' = The moisture content of salted fish in %;

S = The salt content of fresh fish in % (usually considered as 0);

S' = The salt content of salted fish in %.

We too made an attempt to calculate the possible output of salted anchovy, using the above-mentioned Turpaev formula. But the calculations were impossible in those cases of salting in salt solutions with salt concentrations of 10 % each and 15 %, as well as when salting with dry salt with dosages of 12 % and 15 %, because we obtained H' and S', which were larger than H and S, with the consequence that (H+S) - (H'+S') gave a negative result.

For cases of salting anchovy in 20 % and in saturated solutions, as well as salting with dry salt dosages of 20 % and 25 %, the calculated losses, when using Turpaev's formula, were considerably lower than those found in our research into the weight changes in the anchovy during salting.

The uselessness of Turpaev's formula for calculating the possible output of salted anchovy may be explained by the fact that, with anchovy salting, not only changes of moisture and salt contents took place, but there was also a considerable loss of compact substances in the fish, and the formula does not take these changes into account. Concerning this failure of Turpaev's formula, it should also be remarked that the formula does not take into account the connection between the salted fish output and the temperature conditions during salting. This connection was not only noted in our work and that of other researchers, but also proven in practice.

Results of our experiments concerning the amount of weight lost by the anchovy during experimental saltings under various conditions, correspond with results of other investigators.

According to Dragunov *, the loss of weight in large anchovy when using dry salt dosages of approx. 18 %, was 12.9 %, and with dosages of 22.5 % — 15 %.

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* Dragunov: Investigations of losses during salting of herring, sardine, and anchovy. The Azov Division of VNIRO, 1934.

Table XVII

Anchovy	Salinity of fish (in %)	Salt concentration in fish liquid (in %)	Duration of salting						Loss in fish weight (in % from initial weight at salting		Volume decrease (in % of initial weight at salting)		Moisture content in fish (in %) during salting	
			Dosage of dry salt			Salt concentration in brine in %								
			12	15	20	25	20	saturated	with dry salt	in brine	with dry salt	in brine	with dry salt	in brine
Slightly salted	7-8	11-14	2-3 days	18-24 hrs	16-20 hrs	14-16 hrs	12-18 hrs	10-14 hrs	8-12	6-8	7-10	7-9	55-57	52-54
Medium salted	9-11	14-18	5-10 "	3-4 days	40-60 "	24-48 "	24-48 "	18-36 "	11-15	8-10	10-13	10-12	51-55	49-52
Highly salted	14-15	21-24	-	-	8-10days	4-5 days	-	-	16-19	-	15-18	-	47-49	-

According to Minder /6/, the larger autumn anchovy, having a specific weight of 1.19, lost from 11 - 13 % of its weight after 2 days of salting in brine.

The quality of the salted anchovy (appearance, taste, firmness) prepared by salting in saturated and 20 % salt solutions, and by dry salting with chilling was almost the same. Dry salted anchovy without chilling had a less juicy consistency, but even then there was no great difference.

Table XVII shows results which indicate the required duration of salting anchovy under the different conditions necessary to obtain products with various degrees of salinity, together with the corresponding changes in weight, size and moisture of the anchovy.

Generalizing on the results obtained, concerning the rate of salt penetration into the fish, weight and size changes, as well as loss of moisture and compact substances during salting with dry salt and with salt solutions, we may conclude that brine salting is the most expedient method for the preparation of slightly salted anchovy, when salting should be completed within 15 - 18 hours.

For preparation of highly salted anchovy, when a fairly high rate of salt absorption and dehydration is desirable, it is necessary to use dry salting with a dosage of 25 % of the fish weight.

In the case of preparation of medium-salted anchovy, brine has some advantages over the use of dry salting, since it allows a reduction both of the length of the salting process and of losses. But in practice this method cannot be applied because of the brevity of the anchovy season and the necessity of the simultaneous salting of a large quantity of fish. In order to use this method it would be necessary to construct bulky salting equipment in the fish-preserving plants.

Using the dry salting method, it is possible to prepare medium-salted anchovy in two ways. One is by using barrels with medium salt dosages with a limit of 12 - 15 %, and the other, by using vats with salt dosages of from 20 - 25 %.

Both these methods of dry salting, as well as the brine salting method, are not convenient for use in the factory. Barrel salting requires the expenditure of much labor, and a large area for the barrels for the salted fish to settle; it makes production line organization difficult, and is accompanied by the risk of fish spoilage if the salt is not well distributed, especially when chilling is not applied. The interrupted vat method needs careful control and precise maintenance of the salting conditions, in order to avoid excessive salt absorption by the fish. In this case mechanization of the emptying vat is important.

CONCLUSIONS

Our observations concerning the penetration of salt into anchovy, moisture extraction and weight changes during salting with dry salt and salt solutions, lead us to the conclusion that, for the preparation of medium-salted anchovy, it would be best to apply combined salting methods at the beginning, saturated salt solutions, and then, dry salt.

The preliminary salting in the saturated solutions may take (as for the preparation of slightly salted anchovy) 10 - 12 hours. During this salting time the salt content of the anchovy reaches 7 - 8 %, and it loses 18 - 19 % of its moisture. The size and weight of the fish decrease by an average of 7 - 8 %. In order to receive the same degree of salinity using dry salt dosages of 15 % in barrels, we would need more time (20 - 24 hours). Thus, using a brine solution in the initial and most

important stage of anchovy salting probably enables the attainment of such a degree of salinity, and the salt concentration will be sufficient to inhibit the development of bacterial processes. One advantage of the brine salting method worth mentioning is the even distribution of the salt absorption process over the whole area of the fish, thus eliminating the risk of spoilage which often happens when using dry salt in small dosages, this being the most frequent method used in barrel salting on mechanized production lines.

The semiprepared fish obtained after brine salting should be subjected to dry salting in order to achieve the quality needed for medium-salted fish. Dry salting may be combined with packing, as is done in the case of barrel packing. During the dry salting of the semiprepared fish in the container, a small quantity of brine and a slight 'settling' of the fish will result. But the ratio of fish weight to brine should be preserved in order to maintain production standards. This will enable us to seal the dry salted, semiprepared fish immediately after packing, without a preliminary settling, as is done at present in the usual barrel-salting method. According to our calculations made on the basis of our experiments with the salinity and changes of moisture, weight, and size in anchovy during dry salting in order to obtain a finished product, thequantity of salt to be added to the semiprepared fish after brine salting is 5 %.

The proposed combined method of salting for the preparation of a medium-salted product is much more preferable for mechanized production than the usual barrel method.

In the planning of a mechanized industrial plant for combined anchovy salting, arrangements should be made for the cooling of the anchovy before salting.

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CHANGES IN THE ROE DURING PREPARATION OF PRESSED CAVIAR

(Izmenenie ikry pri obrabotke payusnym peredelom)

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Salmon roe is one of the best of all fish products because it has a good taste and high nutrition value. Examinations of the raw roe of the main species of salmon, sturgeon, sevruga and white sturgeon, as well as the technology of the preparation and storage of soft caviar, were made by Drukker, Lazarevskii, Kolchev, Petrova, Feofilaktov, Shapiro, Makarova, and other authors /1, 3, 4, 5, 6, 8, 9, 10, 12, 13/. Another product, pressed caviar, which is also produced in large quantities, has not been studied to such an extent.

In literature, we do not find any investigations concerning changes during caviar preparation. We know that Dragunov, Okuneva, and Vikteshmaer of the Don-Kuban' division of VNIRO , in the years 1939 - 40 , conducted the first investigations of salt absorption and weight changes of salmon roe, when salting it for various time intervals in brine. They also defined the amount of pressure to be applied to the roe in order to obtain the necessary consistency in the finished pressed caviar (0.1 - 0.2 kg/cm^2). But their work was suspended in 1941 and never brought to a conclusion.

In order to have some means of evaluating the quality of pressed caviar, observations of the nitrogen and acidity changes in the caviar during storage were made in 1929 - 31 by Kolchev and Lazarevskii, and in 1940 - 41, by Vikteshmaer. In 1950 - 51, researches concerning pasteurization of pressed caviar for increasing its stability in storage, were carried out by Makarova, Gerasimov, Kulikov and Sergeeva in VNIRO and in the Mosrybombine, but without positive results.

The studies mentioned above, are all that can be found dealing with the technology of the production of pressed caviar from salmon roe.

Thus, the methods used in industry, and the standards for salting and storage of the pressed caviar are without scientific backing.

In practice, the accepted method has been first the preparation of soft caviar, and from this pressed caviar was produced. The roe selected for the preparation of pressed caviar is kept in a cold store or chiller at a temperature of 0 to 8-10°C . When a large quantity of roe is received, chilling time is prolonged from 4 - 5 to 8 - 10 hours, or even more. When roe is brought from distant fishing sites, storage time is prolonged to as much as 18 - 20 hours.

The effect of the duration of roe storage on the quality and output of the pressed
71 caviar has not yet been defined. Roe salting in brine at temperatures ranging from

36 - 37° to 43 - 44°C has been performed by different caviar specialists, but there are no definite opinions concerning the influence of the brine temperature on the characteristics of the product. The quality of the salt used for preparing pressed caviar varies with different working instructions.

According to NIRKh /2/, salt should not contain more than 0.2 % Ca, 0.03 % Mg. and 0.2 SO_4 (% of the weight of dry salt) whereas, according to the technological instructions, the Ca content should be 0.6 % and Mg 0.1 % .

It is possible that the slightly bitter flavor detected in the freshly prepared pressed caviar was caused either by the use of low quality salt or by a brine of too high a temperature; but we do not have any facts to verify this statement.

We examined roe during the preparation and storage of the pressed caviar, basing our work on a number of factors: 1) Storage time of raw roe before preparation, 2) Brine temperature and the amount of Ca and Mg present in the salt during preparation and 3) Packaging methods and storage conditions of the finished product.

These experiments were made in the Caviar and Balyk factory of the Fish Combine im. Mikoyan, Astrakhan. We prepared pressed caviar from raw roe which had been stored for various lengths of time and, for experimental purposes, sevruga, roe taken from live fish was used. The roe thus obtained was immediately stored at temperatures of 0° and 10°C for 2 or 3 to 24 hours.

Salting was done in brine prepared from top grade Baskunchak salt, as well as with chemically pure sodium chloride to which $CaCl_2$, $MgCl_2$ and Na_2SO_4 had been added, calculated to give the following mixtures:

1. Ca^{++} - 0.2 % and Mg^{++} - 0.03 %
2. Ca^{++} - 0.6 % and Mg^{++} - 0.1 %
3. Mg^{++} - 0.03 % and SO_4^{--} - 0.2 % .

The second variant of the mixture corresponded to the standard of top grade table salt, and the third to that described in the industrial technological instructions concerning the preparation of salmon roe.

Salting was performed in brine prepared from top grade Baskunchak salt at temperatures of 38 - 39° , 41 - 42°, 43 - 44° and 45 - 46°C. During the salting of roe with sodium chloride, the brine temperature in each case was the same, viz., 40 - 42°C.

Salting and storage of the roe were accompanied by manifestations of organoleptic changes, and changes in chemical composition. Upon analysis, we determined the moisture, fat, total nitrogen, ash and sodium chloride contents, using the conventional methods /7/ . In order to follow the changes in protein, we determined the nitrogen content of the water-soluble, salt-soluble and insoluble proteins. The non-protein and the amino acid nitrogen, the volatile bases were also examined. For fat examination, acid, peroxide, and iodine numbers were estimated, and the oxyacid content of the fat was found by dehydrating the roe with sodium sulfate and extracting the oxyacids with ether /7, 11/ .

Changes in Raw Roe during Storage before Preparation

Our organoleptic examination did not disclose any changes in smell, taste, or membrane solidity in roe stored at 0°C for 12 hrs. After storage for 22 - 24 hrs at 0° , the quality of the roe deteriorated because of membrane weakening, and a faint smell of 'dampness' manifested itself.

In roe stored for 6 hrs at 10° , there was an obvious weakening of the membrane, as well as a nuance of 'dampness' in its smell and taste. The roe was also covered by a sticky liquid ('milt') , discharged from the small amount of male roe which had split. After 24 hours of storage at 10°, the roe membrane had weakened considerably , the 'milt' from the split roe had mixed with the rest, and gave the impression of a semi-liquid solution devoid of the granulated structure. The smell of roe was slightly acid, a taste of dampness and acidity were noted.

Table I

Changes in the nitrogenous substances and fat of raw roe during storage

Storage conditions of crushed roe	Content of different forms of nitrogen in the roe						Titrated acidity of roe in mg KOH per 1 g of roe	Fat characteristics	
	in mg %			in m from total nitrogen					
	nonprotein	amino acidic	volatile bases	nonprotein	amino acidic	volatile bases		Acid number	Iodine number
Experiment 1									
Roe taken immediately after the splitting of the membrane	98.6	0	—	2.09	0	—	—	0.62	—
Roe stored at 0°									
4 hours	145.5	13.7	—	3.08	0.28	—	—	0.84	—
24 hours	163.7	14.1	—	3.47	0.30	—	—	1.38	—
Experiment 2									
Roe stored at 0°									
2 hours	81.3	5.0	7.6	1.75	0.11	0.16	0.90	0.43	143.4
6 hours	122.5	13.9	7.6	2.64	0.30	0.16	0.90	0.69	—
12 hours	123.1	16.7	7.7	2.65	0.36	0.17	1.01	0.80	146.2
24 hours	127.4	17.2	7.7	2.75	0.37	0.17	1.01	0.96	—
Experiment 3									
Roe stored at 10°									
6 hours	131.2	19.3	8.6	3.04	0.45	0.20	1.01	1.57	140.4
24 hours	136.5	19.7	9.7	3.17	0.46	0.22	1.01	2.12	143.1

Table I records the results of observations made on the accumulation of nonprotein forms of nitrogen, changes in general acidity, and acid and iodine numbers of fat content during storage.

Thus, according to the results recorded in Table I , storage of roe at

temperature of 0° and 10° C was accompanied by approximately the same small increase in the quantity of non-protein nitrogen and amino acid nitrogen. These changes appeared most clearly in the first 4 - 6 hours. The amount of volatile nitrogen bases in the roe remained practically unchanged, from which we conclude that during 24 hrs of storage even at 10° , the processes of putrefaction had not yet developed, and only protein autolysis had taken place. The percentage of non-protein nitrogen in fresh and in stored roe was 1.7 - 3.5 % of the total nitrogen content, but the basic mass of the non-protein nitrogen (approximately 80 %) was the product of the decomposition of the protein into albumoses, peptones and polypeptides. The amino acid and volatile base nitrogen was not more than 20 % of the total NPN content.

The total titratable acidity of the roe examined at the end of storage had hardly changed, despite the appearance of the acid taste and smell.

The clearest changes were observed in the acid content of the fat, which increased progressively with prolongation of storage. They were most clearly observed upon storage at 10°C . The presence of peroxide and oxyacids in the roe fat was not observed even at the end of the storage period, and no changes in the fat iodine numbers were found either.

The data obtained indicated that fat oxidation and a genuine protein decomposition did not take place in the roe stored for 24 hrs at 0° to 10°C . We can only suppose /11/ that in the time interval mentioned, only a partial disruption of the protein molecules took place, i.e., a severance of the bonds between the polypeptide chains of the different molecules, which increased with the rise in temperature. This gives us a picture of the change in the roe consistency, as well as of the softening and the splitting of the membrane.

Roe Changes during Preparation

The effect of the freshness of the raw roe on the output, chemical composition, and organoleptic characteristics of the pressed caviar. Tables II and III give the results of observations on the output, chemical composition and organoleptic characteristics of the pressed caviar occurring upon processing of the raw roe stored for varying periods of time. The salting of the roe was performed in saturated brine prepared from top grade Baskunchak salt, at a temperature of 40 - 42°C .

From Table II we see that raw roe stored at 0°C for periods up to 12 hrs had no real influence on the output of the pressed caviar, which, under these conditions, reached 73 - 75 % of the weight of the raw roe . Where storage was prolonged to 24 hrs at a temperature of 0° , the output of pressed caviar decreased to 70 % . Increase of storage temperature to 10° , with the resultant weakening of roe membranes and the appearance of split roe resulted in a sharp decrease in output, bringing it down to 56 % .

Probably, the greater losses of pressed caviar prepared from roe stored at 10° are not only connected with the mechanical washing out of the 'milt' discharged from the split roe, but also with the extraction of the nitrogenous substances from the remaining unsplit roe, because roe with weak membranes has to be exposed to brine for longer periods (see Table 2) .

The organoleptic characteristics of the roe stored at 0° for 2 - 6 hrs were good in every case. With roe stored at 0° for 12 hrs, the resultant pressed caviar was slightly glutinous . and with lengthening of storage to 24 hrs, the viscidity was considerably increased.

Table II

The influence of the freshness of the raw roe on the output and organoleptic characteristics of the pressed caviar

No of experiment	Storage conditions of crushed roe		Organoleptic evaluation of raw roe before salting	Duration of salting of roe in seconds	Duration of pressing in seconds	Output of pressed caviar in % of raw roe	Organoleptic evaluation of pressed caviar obtained
	Temp. in °C	Duration (in hours)					
1	0	3	Membrane encasing the roe grains is firm; taste and smell are normal	-	-	75.1	Consistency normal; softness medium; taste and smell pleasant, with clearly pronounced "pressed caviar" flavor; a specific slight bitterness in the taste
2	0	6	Same	-	-	73.0	Same
3	0	2	"	80	60	73.2	"
	0	6	"	90	50	72.5	"
	0	12	"	100	30	73.2	Consistency slightly glutinous; taste and smell normal, the same as in previous samples
	0	24	Membrane encasing the roe grains is somewhat softer; there is a slight smell of "dampness	110	30	70.0	Consistency more glutinous than in previous sample; taste and smell without noticeable changes.
6	10	6	Roe grains become soft, damp (and stick to each other); both smell and taste have a nuance of "dampness"	100	30	56.0	Consistency glutinous; taste and smell normal; the caviar has a stronger salinity in taste.
	10	24	Membranes encasing roe grains are greatly weakened, some roe grains split open and a considerable amount of "milt" is discharged; the smell is slightly sour; the taste is slighty sour with a nuance of "dampness"	140	30	55.9	Same

Table III

The chemical composition of the pressed caviar obtained from raw roe of varying freshness

No of experiment	Storage conditions of crushed roe before processing		Composition of fresh roe in %					Composition of pressed caviar in %						
	Temp. in °C	Duration (in hours)	Moisture	Fat	Total nitrogen (N)	Protein (N x 6.25)	Ash	Moisture	Fat	Total nitrogen (N)	Protein (N x 6.25)	ash		Concentration of NaCl in roe juice (in %)
												Total	Including NaCl	
1	0	3	52.6	19.03	3.80	23.75	1.30	40.05	19.00	5.30	33.12	4.58	4.08	9.2
2	0	6	56.27	19.00	4.29	26.81	1.37	40.16	18.40	5.67	35.44	4.84	4.47	10.0
3	0	2	52.64	18.80	4.64	29.00	1.48	37.56	17.39	5.74	35.87	5.11	4.26	10.2
	0	6						37.37	17.93	5.47	34.18	5.09	4.61	11.0
	0	12						38.19	18.90	5.20	32.50	5.05	4.63	10.8
	0	24						38.00	15.69	5.25	3 .81	5.07	4.80	11.2
4	10	6	56.09	18.47	4.31	26.93	1.50	37.24	15.61	5.42	33.87	5.16	4.72	11.2
	10	24						.39.31	18.40	5.19	32.43	5.16	5.04	11.4

After storage at 10° for 6 and for 24 hrs the pressed caviar was much more glutinous, but in each case it was of good quality. In a comparison of the chemical composition of fresh roe and pressed caviar prepared from it, it is possible to see that the relative fat content of the pressed caviar remained approximately the same, but the moisture content decreased (by 1.4), while the protein content increased (by 1.2 - 1.3). There was also an increase (approximately 3 times) in the relative contents of the mineral substances because of salt absorption.

According to weight calculations and chemical analysis of the raw roe and of the finished pressed caviar, we calculated the amount of moisture, nutritious nitrogen , and fatty substances extracted from the roe during salting in brine and which were lost together with the liquid oozing out upon pressing of the roe (Table IV).

Table IV

Losses of moisture, nitrogenous substances, and fat in roe during preparation of pressed caviar

No of experiment	Conditions of crushed roe before processing		Loss in % from initial content in raw roe		
	Temp. in °C	Time (in hours)	Moisture	Nitrogenous substances	Fat
1	0	3	42.8	—	25.0
2	0	6	47.9	3.5	29.3
3	0	2	47.8	9.5	32.3
	0	6	48.5	14.6	30.9
	0	12	46.9	18.0	26.4
	0	24	49.5	20.8	41.6
4	10	6	62.8	29.6	52.7
	10	24	60 [illegible]	32.7	44.3

According to Table IV, when roe was stored at 0° for 6 hrs, the fat loss was 25 - 30 % and the loss of nitrogenous substances, 10 - 15 % . With prolongation of storage at 0° for 24 hrs, and also during storage at 10° for 6 hrs and more, the loss of nitritious substances from the roe increased considerably. Protein loss was 20 - 30 %, and that of fat, 40 - 50 % .

Some idea of the amount of nitrogenous substances and fat lost during the application of pressure to the roe can be obtained from the results recorded in Table V. However, the authors of this analysis were probably unable to collect all the liquid lost and to calculate the quantity of the liquid extracted from the roe under pressure, due to peculiarities in the pressing equipment.

Moisture lost by the roe during processing, where storage was at 0°C , was 43 - 49 % . The data obtained on moisture losses coincide with results obtained by Dragunov and Okuneva (The Azov division of VNIRO), which established a moisture loss of 30 % during salting and during pressure, of up to 20 % of the initial moisture content.

Thus, our observations indicated that changes in raw roe during storage before processing, manifested themselves by an increase in the loss of nutritious substances, a decrease in the output of the finished pressed caviar, and a deterioration of the consistency of the caviar because of the onset of viscidity. Storage temperature had a greater effect on the losses than storage time.

Table V

Chemical composition of the liquids extracted from the roe during the pressing process (According to data from the Astrakhan Division of VNIRO)

Number of sample	Content in %				
	Moisture	Compact substances	Fat	Protein	Salt
1	78.17	26.83	7.31	5.36	17.19
2	75.13	24.87	2.50	—	16.22
3	77.08	22.92	1.40	1.67	17.44
4	76.68	23.32	1.55	1.79	19.50
5	74.34	25.66	3.52	—	21.70
6	79.69	24.31	3.52	3.63	16.60
7	77.20	22.80	2.34	3.41	15.25
8	75.37	24.63	4.41	3.63	16.60

According to our results, raw roe should be stored at a temperature of 0°C for approximately 5 - 6 hrs . At higher temperatures, storage should not be attempted.

Changes in Nitrogenous Substances and Fat in Roe

Tables VI and VII give the results of observations made on the contents of various forms of nitrogen before and after processing. The relative contents (in % of total nitrogen), of the total protein nitrogen and especially of the nitrogen of salt soluble protein in raw roe stored at 0° for 6 hrs , were less, and the nitrogen of the nonsoluble protein was more than in the raw roe stored at the same temperature for only 2 hrs. This indicates that during storage at 0° for 6 hours, hydrolysis of the proteins and denaturation of the ichthulinic proteins begin to take place, causing a decrease in solubility.

Table VI

Contents of the different forms of protein nitrogen in roe

Number of experiment	Duration of storage of crushed roe at 0° before processing	Material investigated	In % of raw material					In % of total nitrogen content			
			Total nitrogen	Protein nitrogen	Nitrogen of salt soluble proteins	Nitrogen of water soluble proteins	Nitrogen of non-solubel proteins	Protein nitrogen	Nitrogen of salt soluble proteins	Nitrogen of water soluble proteins	Nitrogen of non-soluble proteins
1	2 hours	Raw roe	3.80	3.73	2.96	0.35	0.42	98.2	77.9	9.2	11.1
		Pressed caviar	5.30	5.16	3.65	0.41	1.10	97.4	68.9	7.7	20.8
2	6 hours	Raw roe	4.29	4.19	3.01	0.38	0.80	97.8	70.1	9.0	18.7
		Pressed caviar	5.67	5.43	3.74	0.23	1.46	95.8	65.9	4.2	25.7

In both experiments, the nitrogen content of both salt-soluble and water-soluble proteins in the roe decreased considerably after processing, while at the same time the nitrogen content of the nonsoluble proteins increased. The decrease in quantity of the soluble proteins can be explained by partial leaching and denaturation during salting of the roe in brine warmed to 40 - 42°, as well as by the loss of soluble proteins together with the brine during the application of pressure.

Table VII

Contents of the different forms of the non-protein nitrogen in roe

Number of experiment	Conditions of storage of crushed roe before processing		Material investigated	In calculation of raw material				In % of total nitrogen		
	Temp. in °C	Time (in hours)		Total nitrogen in %	nonprotein nitrogen	nitrogen of amino acids	nitrogen of volative basics	Nonprotein nitrogen	Nitrogen of amino acids	Nitrogen of volatile bases
					in mg %					
1	0	2	Raw roe	3.80	67.9	0	7.0	1.78	0	0.18
			Pressed caviar	5.30	136.4	26.4	8.0	2.57	0.50	0.15
2	0	6	Raw roe	4.29	96.0	16.0	3.8	2.24	0.38	0.09
			Pressed caviar	5.67	219.0	37.0	8.5	3.86	0.68	0.15
3	0	2	Raw roe	4.64	81.3	5.0	7.6	1.75	0.11	0.16
			Pressed caviar	5.74	126.9	11.5	7.7	2.21	0.20	0.13
	0	6	Raw roe	4.64	122.5	13.9	7.6	2.64	0.30	0.16
			Pressed caviar	5.47	135.6	18.8	7.7	2.48	0.34	0.14
	0	12	Raw roe	4.64	123.1	16.7	7.7	2.65	0.36	0.17
			Pressed caviar	5.20	135.6	18.0	7.7	2.62	0.35	0.15
	0	24	Raw roe	4.64	127.4	17.2	7.7	2.75	0.37	0.17
			Pressed caviar	5.25	171.9	59.1	7.7	3.28	1.12	0.15
4	10	6	Raw roe	4.31	131.2	19.3	8.6	3.04	0.45	0.20
			Pressed caviar	5.42	161.9	28.1	8.6	3.00	0.52	0.16
	10	24	Raw roe	4.31	136.5	19.7	9.7	3.17	0.46	0.22
			Pressed caviar	5.19	183.7	59.1	10.3	3.55	1.14	0.20

Protein denaturation of the roe during salting was verified by sight and touch. The roe became more compact and the "milt' thicker. According to Feofilaktov and Karpov /13/ , in the presence of salt, sevruga roe began to coagulate at a temperature of 37 - 38° , i.e., at a temperature lower than that of the brine in which the roe was salted (40 - 42°) .

The contents of the NPN and the amino acid nitrogen in the finished pressed caviar were in almost every case higher than that of the raw roe (Table VII). No appreciable difference was observed in the contents of the nonprotein forms of nitrogen

in samples of pressed caviar prepared from roe stored by different methods. But as we found in experiment No 3, at a temperature of 0° , prolongation of storage time from 2 to 24 hrs was accompanied by a small but regular increase of NPN in both the roe and the finished pressed caviar. It should be emphasized that a part of the soluble NPN substances is uncontrollably lost during salting and the application of pressure to the roe. Hence the increase of NPN observed upon analysis of the pressed caviar only indicated the presence of some hydrolysis of proteins in the roe during processing and not the characteristics of the degree of hydrolysis which should have been larger than those established by our analysis.

Table VIII indicates results of the examination of the total titratable roe acidity, and also the acid and iodine numbers of the fat. The fat was extracted from the raw roe by sulfuric ether , as mentioned above, and from the finished pressed caviar by extraction and pressure.

Table VIII

Changes in total acidity and roe fat characteristics after preparation

Number of experiment	Conditions of storage of crushed roe before processing		Raw roe			Pressed caviar				
							Acidic number of fat		iodine fat number	
	Temp. in °C	Time (in hours)	Total acidity (in mg KOH per 1 g of roe)	Acidic number of extracted fat	Iodine number of extracted fat	Total acidity (in mg KOH per 1 g of caviar	Pressed out	Extracted	Pressed out	Extracted
1	0	2	1.26	0.38	159.6	1.65	0	0.94	152.5	151.5
3	0	2	0.90	0.43	143.4	1.34	0	1.35	149.2	142.7
	0	6	0.90	0.69	155.6	1.34	0	1.39	136.8	141.9
	0	12	0.01	0.80	146.2	1.40	0	1.43	150.2	144.4
	0	24	1.01	0.96	117.9	1.40	0	1.67	152.6	118.5
4	10	6	1.01	1.57	140.4	1.46	0.07	3.41	149.3	140.4
	10	24	1.01	2.12	143.1	1.46	0.26	3.70	186.5	193.1

As seen from Table VIII, the total titratable acidity of the pressed caviar was more than that of the raw roe. In each case the acid content of the fat also increased considerably after processing (on the average by 2) .

It is interesting to examine the characteristics of the fat extracted from the pressed caviar by various methods. According to Table VIII, the fat obtained by extraction and by pressure had the same iodine number, but a different acid content. Unlike the extracted fat, the fat obtained by pressure, in almost all cases contained no free fatty acids.

The iodine number of the fat underwent almost no change after processing, except in one experiment with raw roe stored at 10° for 24 hrs, when a large increase in the iodine number was noted.

We may assume that, in the latter case, the greater changes in the raw roe

before salting caused the formation of decomposition products which were fat soluble, and proved oxidizable during the processing of the roe. If this is true, then the above-mentioned products which decomposed were of a protein origin, because neither peroxides nor aldehydes were found in any of the fat samples taken from either the finished pressed caviar or the roe. This indicates the absence of oxidation of the fat of the roe during processing.

The effect of the salt content and the brine temperature on the quality of the pressed caviar. It has been mentioned before, that, in order to establish the effect of the salt content and the brine temperature on the process of salt obsorption and on the quality of the pressed caviar, two series of experimental saltings were performed. Fresh sevruga roe taken from one batch of fish was salted. In one series of experiments the roe was salted simultaneously in brine made from Baskunchak salt, and in chemically pure sodium chloride to w which were added various quantities of Ca and Mg salts and of sodium sulfate.

In the second series of experiments the roe was salted in brine prepared from Baskunchak salt which was warmed to various temperatures. The conventional method of brine preparation was used, with preliminary boiling and settling according to instructions. The ratio of roe weight to brine was 1 : 5 . Samples of the warmed brine thus prepared were taken for analysis, before the introduction of the roe. Salting and pressing times were precisely recorded. The output, moisture and salinity of the finished pressed caviar were examined in detail. The roe salting was performed by an expert, N.A. Putyatinskii, under the direction of instructor M.N. Filimonov.

From the brine analysis the chemical composition of the salt content was calculated (Table IX)

Table IX

The salt composition of different brine samples

Kind of salt used for brine preparation	Quantity of admixtures added according to calculation in %			Actual content of dry salt in %			
	$Ca^{\cdot\cdot}$	$Mg^{\cdot\cdot}$	SO_4''	Cl'	$Ca^{\cdot\cdot}$	$Mg^{\cdot\cdot}$	SO_4''
Industrial Baskunchak salt *	—	—	—	60.53	0.039	0.011	0.091
Same**	—	—	—	60.50	0.031	0.010	0.124
Chemically pure sodium chloride (NaCl)	—	—	—	60.57	0.021	0.009	0.046
Same with addition of $CaCl_2$	0.20	0.03	—	60.60	0.158	0.024	0.042
Same **	0.60	0.10	—	60.69	0.534	0.107	0.036
Same with addition of $MgCl_2$ and Na_2SO_4 .	—	0.03	0.26	60.45	0.013	0.024	0.186

* Brine was used in a series of experimental tests with investigation of different salt content.

** Brine was used in a series of experimental tests of caviar salting in brine of different temperatures.

According to the data in Table IX, it can be seen that the Baskunchak salt was sufficiently pure and that its composition was similar to that of chemically pure sodium chloride. In brine prepared from chemically pure sodium chloride, to which salts of

Ca , Mg, and sulfate had been added, the actual amount of the latter was close to that calculated.

Table X records results of observations made on the salting methods, output, moisture, and salinity of the roe.

The results of the experiments indicated that the completion of the salt absorption, characterized by organoleptic indices, during salting in brine at a temperature of 43 - 46°C , was faster than during salting in brine at a temperature of 38 - 42° , In the experiments with brine prepared with a different salt, less salting and pressure were needed in the case of the chemically pure sodium chloride. It was also noted that in brine prepared from chemically pure sodium chloride to which Ca and Mg salts had been added, (0.6 % Ca and 0.1 % Mg), the roe thus salted was of a more compact consistency than in the other cases. The most 'delicate' action on the roe was that of brine made from chemically pure sodium chloride.

Table X

Salting methods, output, moistness and salinity of roe

Number of sample	Kind of salt used for preparation of brine	Brine Temp. in °C		Duration of salting in brine	Duration of pressing of caviar in seconds	Caviar output in % of raw roe weight	Composition of caviar in %		
		at the beginning of salting	at the end of salting				Moisture	Salinity	Salt concentration in caviar juice
	I. Experiments with brines of different temperatures								
1.	Industrial Baskunchak salt	39	37	120	70	71.9	40.94	4.09	9.1
2.	Same	42	40.5	130	80	75.0	40.05	4.08	9.2
3.	Same	44	43	100	70	75.9	36.84	4.67	11.2
4.	Same	46	45	100	50	74.5	36.01	4.05	10.1
	II. Experiments with brines of different salt content								
5.	Industrial Baskunchak salt	40	39	105	75	73.0	40.16	4.47	10.0
6.	Chemically pure sodium chloride	42	40	90	60	73.0	37.36	4.49	10.7
7.	Same with addition of 0.2 % Ca^{++} and 0.03 % Mg^{++} .	42	40	135	70	70.8	37.00	4.00	9.8
8.	Same with addition of 0.6 % Ca^{++} and 0.1 % Mg^{++} .	42	40	100	70	70.8	36.95	4.50	10.9
9.	Same with addition of 0.03 Mg^{++} and 0.2 % SO_4'' .	43	41	110	75	75.1	36.36	4.24	10.5

The temperature within the pressed mass of the roe was close to that of the brine in which the roe was salted. A smaller moisture content (Approximately 36 - 37 %), was found in the roe which had been salted in brine at higher temperatures (43 - 46°) than in roe salted at lower temperatures (40 - 41 % at 39 - 42°) .

The increase of temperature also helped to bring about a slight increase of salt concentration in the roe sap (from 9 to 10 - 11 %). Differences in salt composition had no influence on roe moisture and salinity.

The prepared samples of pressed caviar were packed in glass jars, hermetically sealed under vacuum, and stored in a freezer at -2°C . Tasting of the caviar by a number of specialists a few days after preparation of the samples, and after 1½ months of storage, established the following:

1. Increasing the brine temperature from 38 - 39° to 45 - 46° caused some intensification of the caviar aroma, together with some compactness and the appearance of viscidity. But there was no great difference between samples, and they were all classified as good.

A small, specific nuance of bitterness was noted in all samples, which was not dependent on the brine temperature applied during the salting.

2. Caviar samples prepared with the use of different salts varied considerably in taste and consistency. In caviar prepared with Baskunchak salt, the consistency was normal and of average softness. Caviar salted in brine prepared from chemically pure sodium chloride had a very soft and even mushy consistency, while in other samples the consistency was rather hard.

The caviar flavor was almost entirely absent from samples salted in pure sodium chloride and sodium chloride to which had been added 0.6 % Ca and 0.1 % Mg salts, but in other caviar samples it was very marked.

The taste of the caviar prepared with sodium chloride to which had been added the above-mentioned quantities of Ca and Mg salts, had a considerable aftertaste of bitterness. In other samples, most specialists noted the presence of the same slight nuance of bitterness, but some specialists noted that caviar prepared with pure sodium chloride had no bitter taste.

CONCLUSIONS

1. Changes occurring in raw roe during storage before processing caused a lower output of pressed caviar and a deterioration in the quality, manifested by the appearance of viscidity.

In order to avoid the low output of pressed caviar, as well as the viscidity, fresh roe should be stored at a temperature of approximately 0°C , for not more than 5 - 6 hrs.

The output of pressed caviar from fresh roe stored under these conditions is 73 - 75 % .

2. During processing, the roe lost approximately 50 % of its moisture and a considerable amount of its nutritious substances: 25 - 30 % of fat, 10 - 15 % of nitrogenous substances.

3. Simultaneously with the loss of a part of the nitrogenous substances and fat during the processing, hydrolysis and denaturation of the proteins, and hydrolysis of the fat took place. Fat oxidation during the process was not detected.

4. The brine temperature during salting had an influence on the quality of the caviar. Increasing the temperature accentuated the caviar "aroma" although at the same time the caviar became more compact and viscid.

According to the data obtained, brine at a temperature of 38 to 44 - 45°C can be used for roe salting. In the regulation of the brine temperature in practice, the temperature of the roe should be taken into account.

5. Increasing the Ca and Mg salts, content in the salt gave the caviar an aftertaste of bitterness. The quantity of these additives which can be added to the salt used in the preparation of the pressed caviar should be limited to 0.2 % Ca, and 0.03 % Mg salts in % of the weight of the dry salt.

6. A slight nuance of bitterness was detected in all samples of pressed caviar prepared from fresh roe with salt of high quality and brine of medium temperature. Such a nuance should be recognized as a specific taste of the pressed caviar.

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INVESTIGATION OF THE PROPERTIES OF SMOKE GENERATED FOR CURING FISH

(Issledovanie svoistv koptil'nogo dyma)

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In order to regulate the process of fish curing, the application of a mobile smoke generator to operate in conjunction with the smoke kilns is recommended.

It is believed that generating the smoke outside the actual curing chambers will bring about a number of improvements, the most important of which is the possibility of supplying conditioned smoke to the chambers. The latter requires a study of the properties of smoke, and the relationship existing between the manner in which it is generated and the quality of the cured fish.

A great deal of research has already been devoted to the study of aerosols, among which is smoke, as well as to the process of fuel gasification and dry distillation of wood pulp. However, very little research has been carried out relating to the application of smoke to the curing of food products.

Consulting the papers pertaining to the study of the composition and properties of smoke used for curing, it is important to note the comprehensive study carried out by Pettit and Lane /14/, elucidating the dependence of the chemical composition of smoke on the quantity of air supplied in the process of burning beech pulp. The works of Cutting /12/, Lovern /13/ and Schoones /14/, while indicating the presence of certain substances in smoke, also mention several difficulties encountered in the study in smoke, due to its complex composition. The work carried out by Surzhin /8/ and Makarova /5/ on the production of the liquid curing substance, indicates at least to some extent the qualitative composition of smoke: furthermore, the work of Podsevalov on the technology of fish smoking /4/ also contains certain data on the composition of smoke.

Up to the present time the relationship between the composition of smoke and the quality of the smoked fish has been almost completely neglected. Consequently, it is still unknown which specific smoke components are those instrumental in imparting flavor and color to the fish. Similarly, the conditions under which smoke should be generated to yield the necessary curing properties are as yet unknown.

The results of the study on the curing properties of smoke carried out by the author in conjunction with M. E. Kand, N. N. Sakharova and A. B. Emshanova, are given in this article.

Influence of Temperature and Relative Moisture on the Density of Smoke

It is known that the color and flavor of smoked fish, as in all smoked food products, are connected with the quantity of smoke present in the curing chamber;

an inadequate quantity of smoke retards curing, while an excessive quantity of smoke results in over-curing. In accordance with this, the obvious course is to equip the smoke kilns with mobile smoke generators. This, however, presents the problem of how to regulate the supply of smoke to the curing chambers and how to construct an appropriate apparatus for this purpose. On the basis of an experiment to determine the required smoke density in various industrial installations /7, 10, 11/, a special control apparatus was constructed for regulating the smoke density in the curing chambers - a "smoke meter" - as outlined in Figure 1. The question of the practicability of such an apparatus arose due to the necessity of clarifying to what extent the smoke density in the curing chambers is influenced by variations in temperature and relative moisture in view of the fact that, insofar as we know /1, 2, 8/, the presence of water vapor and the temperature of the environment exert a substantial influence on the stability of aerosols. Experiments were carried out using a special laboratory contrivance (Figure 2), designed for the purpose of separating the smoke into its component parts. The fuel was consumed in a small generator, 1, the air being furnished by a fan, 2, and its supply regulated by a valve, 3. The temperatures of the burning fuel and of the smoke were controlled by a thermocouple, 4, and a mercury thermometer, 5.

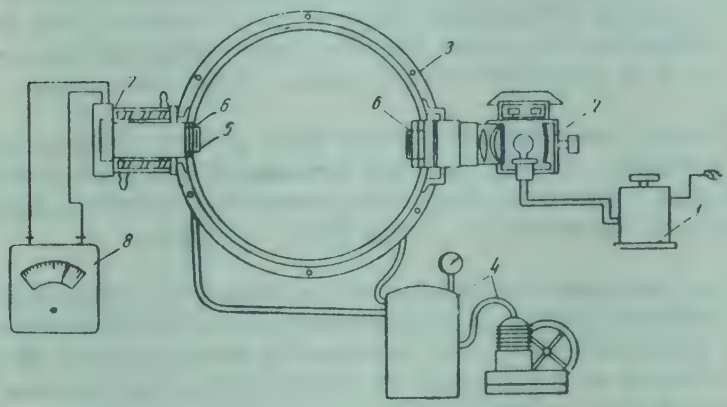


Figure 1. Smoke meter - 1. transformer; 2. illuminator; 3. smoke conductor; 4. compressor; 5. slots for blowing protective glass pans; 6. protective glass pans; 7. photoelement; 8. indicator of smoke density (microammeter).

From the smoke generator the smoke was conveyed to the curing chamber, 6, which was heated by gas burners, 7. The temperature and relative moisture of the gas medium were measured by dry and wet recording thermometers, 8. The desired relative moisture level was maintained in the chamber by means of steam supplied through an atomizer, 9, connected to a steam generator, 10.

The density of smoke in the chamber, as in the smoke meter, was controlled by changes in the photocurrent, caused by changes in the intensity of the light beam which was furnished by an illuminator, 11, to the photoelement, 12, and registered by a microammeter, 13. Constant current was fed to the illuminator from a gas rectifier, 14, supplied from the lighting system through a current stabilizer, 15. The voltage of the illuminator was regulated by a rheostat, 16, controlled by a voltmeter, 17.

The optical system of the illuminator was constructed in such a manner that the light beam had the same cross section area all along its path through the chamber, 6. In order to prevent clouding of the optical system the chamber was

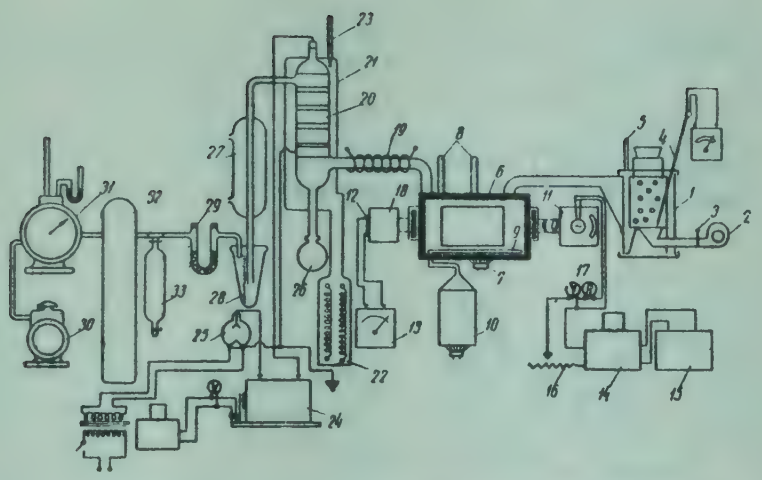


Figure 2. Laboratory installation plan for smoke separation

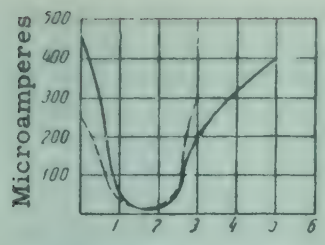
furnished with special protective glass. To avoid any possible effect on the magnitude of the photocurrent by the heat of the chamber, a selenium photoelement was emersed in a special attachment, 18, cooled by tap water.

Smoke from the chamber, 6, entered an electrofilter, 20. To avoid the condensation of substances contained in the smoke, the smoke conductor connecting the chamber with the electrofilter was heated by an electrospiral, 19. To prevent the precipitation of smoke vapors in the electrofilter, the latter was enclosed in a jacket, 21, to which heated air from an electrofurnace, 22, was supplied. The temperature in the jacket of the electrofilter was measured by a mercury thermometer, 23. The electrofilter, in the form of a cylindrical glass tank, was enveloped by a thin strip of red copper. A constant current with a voltage of 50 kilovolts was supplied from an inductor, 24, to the electrofilter, the current being rectified by a kenotron, 25. The precipitated particles of tar and carbon black were collected in a fluke, 26, and the vapors and gases were directed to a cooler, 27. The condensed vapors were assembled in a vessel, 28, and in a calcium chloride pipe, 29. The smoke was sucked off by means of a vacuum pump, 30, connected to a gasometer, 31, and a receiver, 32. The test samples of dry gases were selected for analysis by means of a gas pipette, 33. The smoke translucence was measured in the smoke meter of the apparatus and in the chamber, 6. The density of the smoke is inversely proportional to translucence. Thus, the increase in translucence expressed in microamperes conforms to the decrease in density, while the decrease of translucence conforms to the increase in density.

The apparatus described above permitted not only the measuring of smoke density and its variation within certain desired limits but also the modification of temperature and relative moisture within the desired limits.

To check the stability of the indicated smoke density in the chamber the same quantity of fuel was placed in the smoke generator, maintaining the air blast at a constant level.

The data in Table 1 indicates that, under conditions identical to those under which the experiment was carried out, the results of the determination of the smoke density in the chamber were very close.

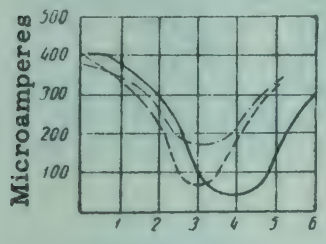


a

Minutes

—— Temperature 83°; Relative moisture 10%

---- Temperature 95°; Relative moisture 66%



b

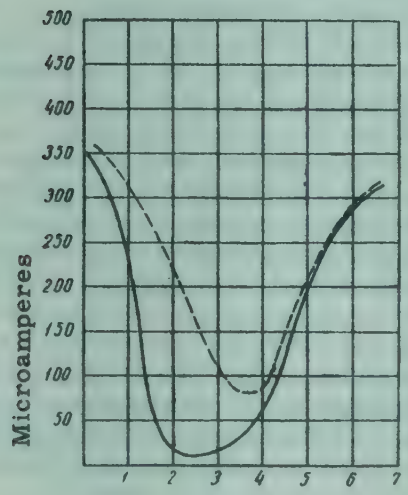
Minutes

—— Temperature 125°; Relative moisture 13%

---- Temperature 130°; Relative moisture 60%

—·— Temperature 130°; Relative moisture 86%

Figure 3. Influence of relative air moisture on smoke density
a - at temperature below 100°; b - at temperature above 100°



Minutes

—— Temperature 31-37°

---- Temperature 117-147°

Figure 4. Influence of air temperature on smoke density

Table I

Changes in smoke translucence in the smoke chamber during combustion of 5 g of wood

Time in seconds	Translucence of smoke in microamperes,		
	Experiment I	Experiment II	Experiment III
0	450	440	440
15	400	400	400
30	300	300	300
45	200	200	200
55	100	100	100
60	50	50	50
65	20	20	20
70	10	10	10
75	5	5	5
80	0	3	3
85	0	0	0
90	0	0	0
95	5	2	0
100	10	5	5
110	30	30	40
120	100	100	100
130	200	200	200
145	250	250	250
160	300	300	300
180	350	350	350
200	400	400	400
—	—	—	—

The results of the determination of the smoke density at various temperature and relative moisture levels are given in Figures 3 and 4. It can be seen from Figure 3a that the modification of the relative moisture from 10 to 66% had practically no influence on the smoke density at temperatures up to 100°. Simultaneously, at a temperature of above 100°, an increase in relative moisture resulted in a decrease in smoke density (Figure 3b).

A decrease in smoke density was observed when a rise in temperature occurred in the chamber, while the relative moisture level remained constant (Figure 4).

From this it follows that smoke density should be measured at predetermined temperature and relative moisture levels.

Using the apparatus described we endeavored to establish the dependence of the duration of fish curing on the smoke density. For this purpose we suspended sprats on rods in such a manner that they should not obstruct the light beam directed from the illuminator to the photoelement. In the course of curing the temperature and relative moisture levels in the chamber were maintained within the above optimal range. Thus, it was established that at a smoke density of 5-30 microamperes the curing process lasted 25 minutes, at a smoke density of 40 - 80 microamperes, approximately 45 minutes, while at a smoke density of 100 microamperes or more it lasted more than one hour. In these experiments it was considered that adequate curing of the fish had taken place when it acquired a light golden color.

The Interdependence of Smoke Density and its Composition

As is commonly known smoke is a polyphasic aerosol, and various gases formed in the fuel burning process constitute its dispersion medium, while the vapors, tars and carbon black constitute its dispersional phases. The composition of the indicated substances in smoke in relation to its density, is of special interest. Consequently, experiments were carried out in the following manner: aspen pulp finely chopped (5 x 5 x 30 mm) was burned in a predetermined supply of air, and the smoke formed thereby was conveyed from the chamber into an electrofilter with the aid of a vacuum pump. The precipitated amount of tar and the unburned particles (carbon black) remaining after the experiment were washed with alcohol and collected in a flask. The alcohol was then filtered through weighed filter paper, for analysis of the components. The filter was then thoroughly washed with alcohol and weighed after drying. From the difference in the weight it was possible to determine the quantity of the unburned particles.

The filtered solution of tar was diluted to the desired volume with alcohol. Thereafter, a specific quantity of the solution was transferred, by means of a pipette, to a weighed box with paper funnels where the alcohol was evaporated, the residue being dried for four hours at a temperature of 105°, and subsequently weighed. From the weight of this residue the total weight of the tar contained in the entire volume was calculated.

The vapors passing through the electrofilter were conveyed to a chilling chamber. The residual mass was collected in a measured receiving flask of the chilling chamber, and the uncondensed vapors were collected in a U-shaped pipe filled with potassium chloride. The total amount of the liquid collected in the receiving flask, and the weight of the vapor absorbed by the potassium chloride showed the quantity of the condensate. The quantity conveyed through the gas system was measured by a gasometer located in front of the vacuum pump; in the calculations the meter readings were brought to the normal volume. The amounts of tar, unburned particles, condensate, and gaseous products were calculated in grams per 1 m^3 of smoke, and in percent of the weight of the smoke. The results of the analysis are given in Tables II and III.

Table II

The dependence of the composition of aspenwood smoke on its density

Smoke density in microamperes	Temperature in °C	Relative humidity in %	Weight of condensate in g/m^3	Weight of tar in g/m^3	Weight of unburnt particles in g/m^3	Weight of gaseous products in g/m^3	General weight of smoke in g/m^3
6.4	102	25.9	174.0	11.9	0.60	948	1134.5
60.4	100	21.9	114.6	5.4	0.450	950	1070.4
123.1	102	17.7	93.0	4.3	0.505	951	1048.8

Table III

Changes in the relative composition of component parts of aspenwood smoke depending on its density

Density of smoke in microamperes	In % of the weight of whole smoke			
	Tar	Condensate	Unburnt particles	Gaseous products
6.4	1.05	19.3	0.053	79.597
60.4	0.73	10.7	0.051	88.519
123.1	0.42	8.9	0.048	90.632

Tables 2 and 3 indicate that the basic mass of smoke constitutes gases followed by vaporous substances, tar, and, finally, unburned particles. The relative contents of tar, vaporous substances, and unburned particles decrease in proportion to the smoke density. It can therefore be assumed that any significant factor exerting an influence on a decrease of smoke density, will similarly lower the tar content. However, the influence of any variation in the quantity of unburned particles is relatively insignificant.

In order to verify the latter condition a precipitated fraction of smoke and its unburned particles was analyzed. The results of these analyses are given in Table 4. The data obtained did not reveal any relationship between a change in the quantity of unburned particles and the smoke density. In this connection, it is of special significance to note that in Experiment 8, a sharp increase was observed in the quantity of unburned particles in the tar. It has been assumed that the cause of this was the use of birch denuded of bark in this experiment. As is known, workers engaged in curing processes are reluctant to use birchwood, especially if it is without bark, as this leads to a deterioration in the quality of the cured products, with particular reference to the color.

Table IV

Quantity of unburnt particles, per 1 g of tar

No of experiment	Kind of tree	Density of smoke in microamperes	Weight of unburnt particles in g
1	Alder	8.8	0.058
2	Aspen	6.4	0.050
3	Birch	5.4	0.035
4	Pine	8.0	0.032
5	Fir	8.9	0.044
6	Alder	58.8	0.053
7	Aspen	60.4	0.058
8	Birch	62.9	0.225
9	Pine	50.1	0.020
10	Fir	50.4	0.012
11	Alder	106.4	0.057
12	Aspen	123.1	0.116
13	Birch	126.1	0.125
14	Pine	100.0	0,028
15	Fir	98.9	0.016

Figure 5 shows curves indicating the interdependence of smoke density and its tar content, as found in experiments carried out with various kinds of wood. The curves are alike, and similar in shape to a hyperbole. It is most interesting to note that 1 m^3 of smoke of the same density, produced by various kinds of wood, contains varying amounts of tar. The largest amount of smoke tar was produced in the process of burning alderwood.

Smoke produced by foliaceous wood contains more tar than that produced by brushwood. This is perhaps why foliaceous-wood pulp is preferred to brushwood for curing processes. For curing processes alderwood is considered better fuel than birch or aspenwood.

It is so far unclear why an identical content of tar produced from various kinds of wood pulp has a different rate of light transmission. It is possible that the reason for this phenomenon is the different extent of dispersion of the tar particles in the smoke.

From the above it follows that, in determining the density of the curing smoke, the type of wood employed should be taken into account.

The humidity of the wood pulp is of the utmost importance in the process of smoking. It has been observed that any increase of wood humidity, not only retards the curing process, but also affects adversely the quality of the finished product. In order to determine to what extent the amount of tar and other substances contained in smoke is influenced by the humidity content of the wood pulp, special experiments were carried out, the results of which are given in Table 5.

Table 5 indicates that the amount of moisture contained in wood pulp exerts a substantial influence on the various smoke components. Smoke obtained from wood pulp containing a higher degree of moisture produces less tar and more carbon black and condensate.

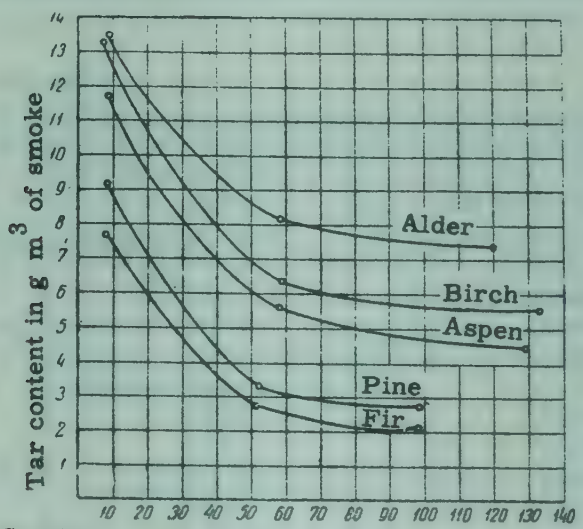


Figure 5. Changes in tar content in the smoke from various kinds of wood in relation to smoke density

Table V

Changes in quantities of tar, unburnt particles, and the condensate in relation to the moisture in wood pulp (without bark)

Moisture in wood pulp in %	Density of smoke in microamperes	Content in 1 m^3 of smoke		
		tar in g	unburnt particles in mg	condensate in ml
43	6.5	8.7	240	180
30	8.8	9.3	-	150
16	8.9	10.8	86	140

Influence of the Type and Moisture Content of Wood Pulp on Acids and Substances Undergoing Bromination Contained in Smoke

Actually, the tar and condensate content of smoke gives only an indirect indication of the significant characteristics of the type of smoke most suitable for the smoking of fish. It is therefore of the utmost importance to trace the changes occurring in other smoke components, particularly acids and substances undergoing bromination in relation to the type of wood used, and also to the presently acceptable quality of the smoked product. Taking the above facts into account, experiments were carried out, whereby birch, alder, aspen, pine and fir wood, with a moisture content of 18 to 35%, was burned. The density of the smoke was from 10 to 30 microamperes.

The acid content of the condensate was determined by titrating it with an 0.1 N solution of barium hydroxide, after passing it through a filter paper. The volatile acids contained in the tar were determined by steam distillation of the tar suspension, and subsequent titration of the distillate by an alkali solution. The substances undergoing bromination, present in the tar and in the condensate were determined by the conventional bromometric method.

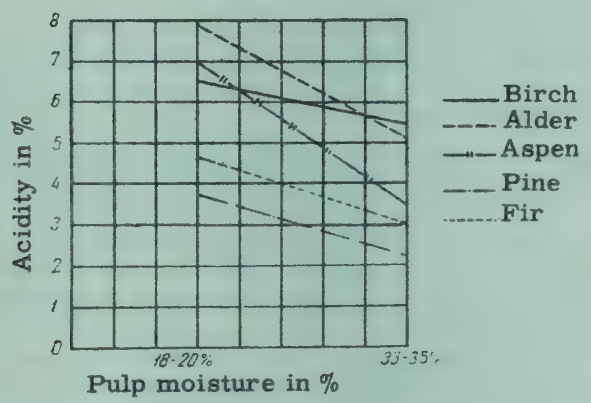


Figure 6. Changes in the acidity of the condensate depending on pulp moisture

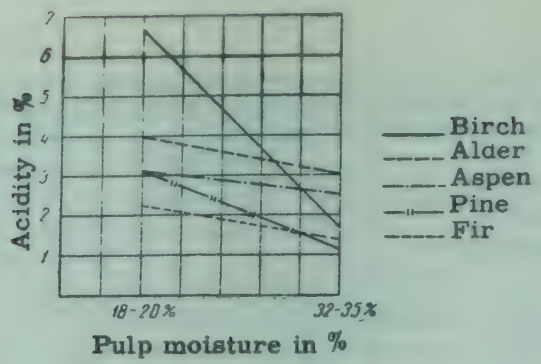


Figure 7. Changes in composition of volatile acids in tar, depending on pulp moisture

Figure 6 indicates that the acidity of the condensate decreases in proportion to the pulp moisture. Experiments have shown that in every case the degree of acidity of the condensate of the foliaceous type of wood pulp is higher than that of the brushwood. With a pulp moisture of 18-20%, the acidity of the condensate in foliaceous wood constituted 6.5-8.0%, while the acidity of the condensate of brushwood constituted 3.5-4.5%.

Any increase in pulp moisture also leads to a decrease in tar acidity, (Fig. 7). The tar acidity obtained from the smoke of foliaceous-type wood pulp (as well as the acidity of the condensate) was higher than the acidity of the tar obtained from brushwood smoke. The highest content of tar acidity was found in birchwood smoke. Birchwood smoke, therefore, which has the highest acidity content as compared with other types of wood, has an unavoidable effect on the finished product; thus fish cured by birchwood smoke have a higher acidity content.

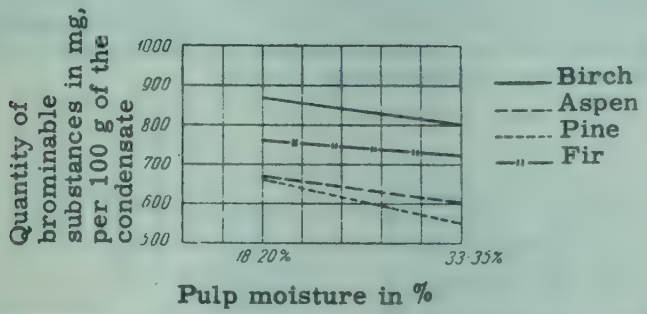


Figure 8. Changes in composition of brominable substances in the condensate in relation to pulp moisture

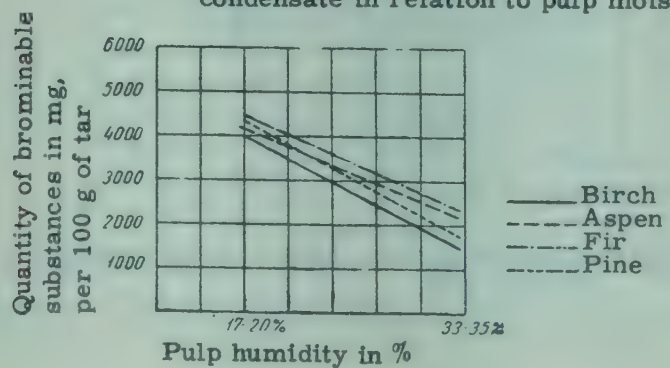


Figure 9. Changes in the content of brominable substances in the tar depending on pulp moisture

An increase in pulp moisture produces a decrease in the quantity of substances undergoing bromination present in the condensate and in the tar (Figures 8 and 9). At a temperature of 80-120° the content of substances susceptible to bromination in the condensate varied from 550 to 1,000 mg per 100 ml. Under these temperature conditions the quantity of substances susceptible to bromination in the tar constituted 1,500-3,500 mg per 100 g.

No peculiarities characteristic of the various types of pulp have been found in the quantity of substances in the tar susceptible to bromination.

The experimental data obtained permit a critical assessment of the role of tar and condensate in the smoke used for curing purposes.

Table 5 indicates that the smoke from aspenwood, having a moisture of 16% and a density of 8.9 microamperes, contains 140 ml of condensate and 10.8 g of tar per 1 m^3. The condensate contains approximately 7% acids (Fig. 6), while approximately 3% is contained in the tar (Fig. 7), in conformity with which 1 m^3 of smoke contains 9.8 g acids on account of the acid content of the condensate, and only 0.3 g on account of the acid content of the tar, i.e., 29 times less. The total amount of acidity is approximately 10 g per 1 m^3.

Making an analogous calculation in respect to the substances susceptible to bromination (according to the data indicated in Figs. 8 and 9), we find that the condensate obtained from 1 m^3 of smoke contains approximately 940 mg of these substances, while the tar contains only 450 mg, i.e., 2 times less than the condensate. The total amount of substances susceptible to bromination per 1 m^3 of smoke is therefore approximately 1,300 mg.

Calculations made in respect to smoke obtained from pulp with a moisture content of up to 30% indicate that with an increase in pulp moisture despite an increase in condensate yield, the total acid content in the smoke decreases to 5.5 g, i.e., by 50%, while the quantity of substances undergoing bromination decreases to 1,100 mg, i.e., by almost 16%. In this case the smoke condensate is 22 times more acid than that of the tar, while the content of the substance susceptible to bromination in the condensate is 4 times more than that of the tar.

Although the given calculations are approximate they permit ample assessment of the important influence of pulp moisture on the nature of the smoke, and also testify to the quite important role played by the condensate in the process of curing. To verify this belief an attempt was made to determine the amount of tar deposited on the fish in the course of the curing process. For this purpose 20 weighed microscope slides were suspended in the curing chamber and heated at a temperature of 100° for 20 minutes (to prevent condensation), after which smoke was conveyed to the curing chamber. The smoke density was maintained at a level of 6-10 microamperes, while the temperature in the chamber was close to 100°. When the slides acquired a brown coloration conforming to the approximate color of the finished product they were removed from the chamber, cooled, and weighed. Thereafter the slides were ground and subjected to analysis to determine the quantity of substances susceptible to bromination in the deposited tar. It transpired that on the slides, which had a total surface of 860 cm^2, 0.1414 g of tar, containing 3.134 mg of brominable substances, was deposited.

Assuming that a sprat with an average weight of 25.5 g has a surface of 75.7 cm^2 /6/, this will, according to the indicated surface of the slides (860 cm^2), correspond to approximately 295 g of fish. One kg of adequately smoked fish should contain not less than 50 mg of substances, susceptible to bromination from which it transpires that 295 g of fish should contain 14.7 mg of these substances. However, by means of the smoke tar deposited in the flesh of the fish, only a

maximum of 3.134 mg of these substances, i.e., only 21% of the required quantity, passed into the fish.

From this it follows that even if the maximum amount of the content of substances susceptible to bromination of the tar can be deposited on the fish, it would still be insufficient to impart to the fish the flavor and smell characteristic of the finished product. It therefore appears that the condensate will have to provide the missing 79% of these substances.

To provide the missing quantity of the substances susceptible to bromination it is necessary that 6 ml of condensate be deposited per 1 kg of fish with an approximate surface of 2,800 cm^2.

CONCLUSIONS

The above leads us to conclude that the main role in imparting the requisite flavor to the finished product is performed by the vaporous substances yielded by the burning fuel. In imparting flavor to the fish the tar is a secondary factor, its chief importance being its color-producing quality.

In conformity with the above data the following is an approximate calculation of the quantity of fish that can be cured by 1 m^3 of smoke. If it is necessary to deposit 0.1414 g of tar to impart the required color to fish with a surface of 860 cm^2, consequently 1 kg of fish having a surface of approximately 2,800 cm^2 will require a deposit of tar in the amount of 0.46 g. Assuming that 1 m^3 of smoke, having a density in the region of 8.9 microamperes, has a tar content of 10.8 g, such quantity of tar is sufficient to cure approximately 24 kg of fish. Since 6 ml of smoke condensate is sufficient to cure 1 kg of fish, the amount of 140 ml of smoke condensate contained in 1 m^3 of smoke is sufficient to cure approximately 23 kg of fish.

How smoke is applied in practice, as in the curing of sprats in the curing kilns of the Leningrad type, can be assessed according to the following computation.

In a correctly applied smoking process sprats are cured with a smoke density of 6-10 microamperes for 25 to 30 minutes, i.e., the same duration as indicated in the laboratory apparatus experiments previously mentioned.

On the basis of this assumption, the smoking of fish, using the Leningrad-type kilns, is performed with a smoke density of 6-10 microamperes.

Under experimental conditions such a density was obtained by burning aspenwood with a moisture content of 16%, with an air supply to the smoke generator, at the rate of 7.2 cm^3 per minute. The total quantity of the smoke thereby produced can be calculated approximately from the following equation:

$$V = V_{H_2O} + V_{\text{min. dry gas}} + \Delta L$$

where V = total quantity of smoke gases per 1 m^3, obtained on combustion of 1 kg of fuel;

$V_{\text{min. dry gas}}$ = minimum quantity of dry gases obtained on combustion of 1 kg of fuel of a determined chemical composition.

V_{H_2O} = full volume of water vapor obtained on combustion of fuel of a given moisture, taking into account the moisture entering the smoke generator with the air;

ΔL excess of air supplied to the smoke generator;

Under the conditions of our experiment $V_{H_2O} = 0.99$ m^3/kg;
$V_{min.\ dry\ gas} = 4.569$ m^3/kg and $\Delta L = 2.64$ m^3/kg,
whence $V = 0.99 + 4.569 + 2.64 = 8.2$ m^3/kg.

In accordance with the accepted norms 0.44 m^3 of wood is used for curing one ton of fish. Assuming that 1 m^3 of aspenwood, after a six-month drying period, weighs 365 kg /3/, the weight of 0.44 m^3 will constitute 160 kg. The amount of smoke produced by combustion of this quantity of wood is 1,312 m^3 Inasmuch as 1 m^3 of smoke contains a quantity of tar and condensate sufficient to cure 23 kg of fish, 1,312 m^3 of smoke is sufficient for 30,176 kg of fish, instead of the 1,000 kg according to the present fish-processing norms.

Thus, only 3% of the smoke produced in the Leningrad-type kilns is being utilized.

The suggested index of the degree of utilization of smoke may serve as a useful means of evaluating the production efficiency of smoke-producing kilns.

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INVESTIGATION OF THE ACID PRESERVATION OF FISH AND FISH OFFAL

(Issledovanie protsessa kislotnogo konservirovaniya ryby i rybnykh otkhodov)

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Fish of low nutritional value and fish offal (head, intestines and bones) collected in fish factories are not utilized at present to the fullest extent. Not more than 60% of this material is utilized for the preparation of fish meal, and only a small quantity is used in its fresh state as cattle fodder.

In order to use fresh fish meal and other offal as cattle fodder, it is necessary to find a good method for its preservation, which will make it possible to preserve these products for a sufficient length of time.

Treatment of the fish and fish offal with acids can be considered as one method.

Acid preservation of food and nutritious products is based on the sterilization ability of the acids. The acid can be added from without (marination) or can accumulate within the product itself under certain conditions (siloing of vegetable fodder, fermentation of cabbage etc).

As is well known, microorganisms are sensitive to the reaction of their surroundings and remain alive and active only within a certain limit of pH. The pH optima of some of the more important microbes are as follows /1 and 2/:

Putrefactive microbes	5.0-8.5
Lactic acid cocci	3.5-8.0
Lactic acid bacilli	3.0-8.0
Butyric acid bacilli	4.7-8.5
Moulds	1.0-9.0
Yeasts	3.0-7.0

A number of works devoted to the preservation of fish and fish offal by acids can be found in foreign and local literature. Petersen /16/ described in detail the methods of acid preservation of fish and fish offal suggested by a number of authors. According to Edin /10/, fresh fish and fish offal were preserved in sulfuric acid, added in such a quantity as to obtain a pH not higher than 2. The quantity of acid required in order to attain the aforementioned pH, as proposed by Edin, was calculated by the following formula:

$$x = 0.14a + 0.9b$$

where x = the quantity, in liters, of 50% sulfuric acid to 100 kgs of raw material;
a = the protein content of the raw material in %, and

b = the ash content of the raw material in %.

Olsson /15/, recommended that fish and fish offal be preserved in formic acid and that the pH of the product be not more than 4.5. For the calculation of the quantity of acid required, he proposed the following formula:

$$x = 0.25 + 0.3a,$$

where x = the quantity, in liters, of 90% formic acid to 100 kgs of raw material, and
a = the ash content of the raw material in %.

In 1952, Carl /9/ suggested that fish offal be preserved by the 'fermentation' method. In order to do this, molasses and a bacterial culture of S. plantarum should be added to the offal. The same studies were made by Kreuzer /13 and 14/.

In 1954-55 in Denmark /9/, research was carried out on the preservation of fish offal with calcium formate together with acetic acid. But the application of these mixtures did not shed any new light on the problem of acid preservation of fish.

Local research workers G.V. Gerasimov and A.P. Makashev /7/ also studied the acid preservation of fish.

Despite the above-mentioned studies, the technology of the acid preservation of fish and fish offal is by no means clear. Hence investigations were conducted in VNIRO on the preparation of experimental batches of cattle fodder made from different kinds of non-nutritious fish and fish offal, preserved in different acids. The purpose of these investigations was to ascertain the dependency of the pH on the quantity of acid added to the fish, as well as to check the stability of the preserved product when stored at various temperatures.

The preparation of the different experimental batches of cattle fodder was carried out together with workers from the Vitamin Department of the Mosrybcombine, and the Fat and Meal Factory im. Mikoyan of the Fish Combine in Astrakhan.

The batches of cattle fodder thus prepared were tested by feeding it to cattle and to fur-bearing animals. The investigations were performed at the All-Union Scientific Research Institute of Cattle Feeding, and at the All-Union Scientific Research Laboratory of Fur Farming.

The Relationship between the Quantity of Acid, the pH Value and the Stability of the Preserved Fish during Storage

At the beginning of the research, a number of laboratory experiments were made on the preservation of fish offal in 50% sulfuric acid and in 90% formic acid, according to methods proposed by Edin and Olsson. The quantity of the acid required for the preservation of the offal was calculated according to the formulae proposed by the authors. A short time after mixing the fragmented material with the acids, we examined the resultant pH. These results are recorded in Table I.

From Table I we can see that, in a number of cases, the quantity of acid calculated according to the formulae was not sufficient to give the required pH.

The results were further checked by preserving 2 tons of fresh heads and intestines taken from carp and bream under factory conditions. In order to obtain a pH of 2.1 for the product, in this case, not 5.4% (calculated by the Edin formula) of sulfuric acid, but 6.2%, i.e., 15% more had to be added.

Table I

The ratio between the quantity of the added acid and the pH of the preserved fish offal

Kind of offal	Content in %		Type preserving agent	Acid quantity per 100 g of product according to formula	Estimated pH	pH obtained		
	Protein	Ash				After 9 days	After 20 days	After 30 days
Carp heads	15.3	6.9	50% Sulfuric acid	8.3	2.0	3.2	—	3.7
Carp intestines	17.6	2.4	Same	4.6	2.0	—	3.3	3.2
Bream heads	16.6	8.1	"	9.6	2.0	3.0	3.7	3.8
Bream intestines	14.6	2.5	"	4.3	2.0	2.8	—	—
Flounder heads	14.1	5.8	"	5.4	2.0	2.2	—	—
Flounder intestines	11.4	2.7	"	2.6	2.0	2.3	—	—
Cod (mintai)*	14.5	3.6		5.3	2.0	2.0	—	—
Carp heads	—	6.9	90% formic acid	2.5	4.5	—	4.7	—
Carp intestines	—	2.4	Same	1.0	4.5	—	4.9	—
Bream heads	—	8.1	"	2.9	4.5	—	4.1	4.0
Bream intestines	—	2.5	"	1.1	4.5	—	4.1	4.5
Flounder heads	—	5.8	"	2.0	4.5	4.2	—	—
Flounder intestines	—	2.7	"	1.1	4.5	4.6	—	—

Similar observations were also made in other experiments on the preservation of the heads and intestines of flounder and other fish. During the work, it was observed that the basic factor having an influence on the value of the pH of the preserved mass was the content of the mineral substances.

During analysis of the experimental results obtained, we established that the ratio between the quantity of 100% sulfuric acid (in kgs), which had to be added to 100 kgs of raw fish material, and the content (in %) of the mineral substances was from 1.0 to 1.6 or, on the average, 1.3 . Hence the quantity of acid required to attain a pH lower than 2 in the preserved product can be calculated by the following formula:

$$k = 1.3a,$$

where k = the quantity of 100% sulfuric acid in kgs and
a = the content of mineral substances in %.

In order to ascertain the dependence of the storage time on the value of the pH of the preserved product, a number of experiments concerning the preservation of different raw fish material were made. The preservatives used were sulfuric acid, hydrochloric acid, formic acid, and a mixture of these acids.

Preservation Using Sulfuric Acid

As the preservative, we used 50-75% sulfuric acid. The value of the pH of the various raw materials under experiment fluctuated from 1.3 to 4.7 . Samples of the preserved products were stored at a temperature of 15-33°C.

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*[Apparently Theragra chalcogramma of the Gididae family. Translator's Note]

Thus, according to Table II, the preserved products which withstood storage best (without spoiling) had a pH of 1.8-2.6, whereas those which withstood storage least well (products with the shortest storage time) had a pH of 4.1-4.7 .

Table II

Storage duration of raw fish material preserved with sulfuric acid

Raw material	Quantity of acids in % of weight of raw material	pH of preserved mass	Storage duration before onset of spoilage (in days)	Storage temperature in °C
Intestines and heads of cod (mintai)*	2.3	4.5	50	18-20
Intestines and roe of pike perch	1.0	4.1	50	18-20
Intestines of flounder	2.3	3.8	60	16-18
Intestines and roe of pike perch	2.0	3.2	50	18-20
Intestines and heads of flounder	5.3	2.6	After 120 days no spoilage occurred	15-17
Intestines of flounder	3.4	2.5	Same	15-17
Heads of flounder	6.0	2.4	Same	15-17
Intestines of pike perch	3.0	2.2	85	18-20
Intestines and heads of carp and bream	6.2	1.85-2.4	After 450 days no spoilage occurred	20-33
Intestines of pike perch	4.0	1.8	85	18-20
Uneviscerated cod (mintai)	1.0	4.7	10	18-20
" "	2.0	3.6	20	18-20
" "	4.0	2.0	300	18-20
Uneviscerated navaga	4.0	1.8	After 180 days spoilage occurred	15-17
Eviscerated "	4.0	1.9	Same	15-17

Preservation Using Hydrochloric Acid

For preserving fish and fish offal, a pure 29-36 % hydrochloric acid was used. The results of observations on the stability of the products preserved in hydrochloric acid are shown in Table III. The results indicate that the most stable products had a pH of 1.6-2.4 .

Preservation Using Formic Acid

During storage of raw material using 85 % formic acid as the preservative, spoilage appeared after 15-60 days in the products which had a pH of more than 4.5, while products with a pH of 4.2-4.5 kept well for 100-120 days, and even more.

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* See footnote on previous page

The storage duration times of raw fish material preserved in formic acid are given in Table IV.

Table III

Storage duration of raw fish material preserved with hydrochloric acid

Raw material	Quantity of acid in % of the fish weight	pH of the preserved mass	Storage duration (in days) before onset of spoilage	Storage temperature in °C
Intestines and heads of pike	1	4.7	20	18-20
Intestines and heads of flounder	3	3.7	60	15-17
Intestines and heads of pike	2	3.4	60	18-20
Heads of flounder	3	2.4	After 100 days no spoilage occurred	15-17
Intestines and heads of pike	3	2.2	60	18-20
Mintai—body	2	3.5	20	18-20
Uneviscerated navaga	4	2.3	After 180 days no spoilage occurred	15-17
Eviscerated navaga	4	1.6		15-17

Table IV

Storage duration of raw fish material preserved with formic acid

Raw material	Quantity of acid in % of the fish weight	pH of the preserved mass	Storage duration (in days) before onset of spoilage	Storage temperature in °C
Intestines and heads of cod (mintai)	1.1	4.6	60	18-20
Intestines and heads of pike	0.5	4.6	15	18-20
Intestines and heads of flounder	1.0	4.6	45	15-17
Same	1.7	4.5	120	15-17
Heads of flounder	2.3	4.2	After 100 days no spoilage occurred	15-17
Intestines and heads of pike	1.7	4.0	60	18-20
Uneviscerated navaga	1.8	4.5	After 180 days no spoilage occurred	15-17
Eviscerated navaga	1.8	4.5		15-17

In our own work /6/, a table can be found concerning the amounts of sulfuric, hydrochloric, and formic acids required for preserving different kinds of raw material.

Preservation Using a Mixture of Acids

An experiment in preservation, using a mixture of formic, hydrochloric and sulfuric acids, was also made. During the storage of products preserved in this acid mixture, the best results, as in previous cases, were obtained when the pH of the mass was less than 2. The storage duration times of the raw fish material preserved in this acid mixture are indicated in Table V.

Summing up the results obtained in our experiments, it should be noted that the raw fish material preserved in each of the acids under examination was better preserved when it had a low pH.

Table V

Storage duration of raw fish material stored in a mixture of acids

Raw material	Quantity of acid in % of raw material weight			pH of the preserved mass	Storage duration (in days) before onset of spoilage	Storage temperature in ^{o}C
	sulfuric	hydrochloric	formic			
Intestines of scad mackerel, perch, cod	3	—	0.17	1.5-1.7	60	15-25
Same	—	1.1	0.34	3.3-3.4	60	15-25
Intestines of bass	3.9	—	0.2	0.9-1.4	After 120 days no spoilage occurred	15-20
Body of cod (mintai)	1.0	—	0.2	4.8	20	18-20
Same	2.0	—	0.2	4.0	20	18-20
Same	2.0	—	0.2	3.6	60	18-20

The Influence of Temperature on the Stability of the Raw Fish Material Preserved with Acids

In order to ascertain the influence of temperature on the quality of the product, samples of preserved fish offal (heads and intestines of pike perch and pike), weighing 1 kg, were stored in sealed glass jars at a temperature of 18^{o}-$20^{o}C$, and in a thermostat at 35^{o}-$40^{o}C$. This temperature was chosen in order to establish the possibility of storage on the hottest summer days. During storage the quality of the stored products was tested by their organoleptic characteristics, as well as by the presence of nitrogen of the volatile bases.

Table VI shows results of the stability of the fish offal in various quantities of sulfuric, hydrochloric, and formic acids at various temperatures. Hence, we see that the influence of the temperature on the stability of the preserved mass was less when using sulfuric and hydrochloric acids, even when the pH level of the others was sufficiently low.

The mass of raw material preserved in formic acid at a temperature of 35^{o}-$40^{o}C$ with a pH of almost 4, was more stable than at 18^{o}-$20^{o}C$.

It is possible that the sterilization ability of the formic acid increased with the increase of the temperature.

Table VI

The effect of temperature on the stability of the raw fish material when preserved in acid

Preserving agent	pH of the preserved mass	Storage temperature in °C	Storage duration in days
Sulfuric acid	3.2	18-20	50
	3.1	35-40	25
	2.2	18-20	85
	2.2	35-40	85
	1.8	18-20	85
	1.7	35-40	85
Hydrochloric acid	3.4	18-20	60
	3.0	35-40	15
	2.2	18-20	60
	2.2	35-40	50
Formic acid	4.6	18-20	15
	4.5	35-40	15
	4.0	18-20	15
	4.1	35-40	60
	3.7	18-20	60
	3.9	35-40	115 and more

In industrial investigations made on the preservation of offal using sulfuric acid, 20 barrels of offal (net weight 2,000 kg) were preserved. These results confirmed the good results achieved when using sulfuric acid at high temperatures. In Astrakhan during the summer, heads and intestines of carp and bream were preserved in sulfuric acid at an air temperature of 30°-33°C, and were stored at that temperature for 20 days after which they were sent to the Moscow Oblast, to the Institute of Cattle Breeding. On arrival samples were taken from each barrel and stored at a temperature of 20°C. Observations indicated that the samples of the preserved offal remained in a good condition for 15 months.

The Effect of Pre-cooking of Raw Fish Material on the Consistency of the Preserved Mass

The various types of fish offal, as well as the whole fish, contain proteolytic enzymes which are active in an acid environment. As the result of hydrolytic action of the enzymes and acids, the fish mass preserved in acids gradually became liquid. In order to inactivate these enzymes and prevent the fish mass from turning liquid, the mass was first boiled. The intestines of sea perch taken for experiment were boiled for 15-20 minutes. During the boiling, the intestines disintegrated into small pieces to a considerable degree; hence they did not need cutting. The cooled, boiled mass was then mixed with the acid.

700 kg of intestines were preserved using such a method, and, simultaneously, an equal quantity was preserved without the preliminary boiling.

The unboiled preserved intestines became completely liquid, whereas the boiled ones retained a dense consistency for a longer period. A sample of boiled intestines preserved in sulfuric acid (pH—2.4) showed no change after 15 months of storage at a temperature of 18°-20°C.

The Effect of Mincing of Raw Material on the Stability of the Preserved Mass

Mincing the raw material is not a complicated procedure, but it is sometimes difficult, especially when processing a considerable quantity of raw material in ill-equipped fish plants. In order to simplify the process, experiments were made on the preservation of whole fish and offal without cutting. Thus, whole fish, e.g., navaga and small stock fish, together with the whole intestines of various fish, (navaga, stockfish carp, and others), were submerged in 4% and 6% sulfuric and hydrochloric acid solutions for 2 hours and, after draining off the acid, put into barrels. The pH of the fish mass after the acid absorption decreased to 4.2-4.8 . The preserved mass was stored at a temperature of 15°-17°C.

Table VII records results of observations made on the stability of the fish mass preserved in both the minced and the unminced forms.

Stability of the fish mass when preserved whole or diced — Table VII

Raw material	Method of preservation	Kind and concentration of acid in the raw material in %	pH of the preserved mass	Storage duration (in days) before onset of spoilage
Navaga, Far Eastern, small, uneviscerated	Whole	Sulfuric acid 4%	4.8	25
Same	Diced	Same	1.8-1.6	120
Navaga, Far Eastern, eviscerated	Whole	"	4.2	25
Same	Diced	"	1.9-1.8	120
Intestines of navaga	Whole	"	2.5-2.3	120
Intestines of carp	"	hydrochloric acid, 4%	1.2	45
Intestines of cod and grey mullet	"	sulfuric acid, 2.3%	1.2	20
Same	"	hydrochloric acid, 2.3%	3.1	20
Cod, small, uneviscerated	"	hydrochloric acid, 6%	—	20
Cod, small, eviscerated	"	Same	—	30

Hence, according to our results, unminced raw material can be preserved by acids for not more than 2-3 weeks.

Changes in the Properties of the Raw Fish Material During Acid Preservation and Subsequent Storage

During preservation, as the result of the addition of acids to the fish mass, the pH level decreased, although the general chemical composition did not change.

In Table VIII are given experimental results concerning the changes in the chemical composition of various fish and fish offal after acid preservation.

Table VIII

Chemical composition of the fish mass preserved with acids

Raw material	Content in %			
	Moisture	Fat	Protein (Nx6.25)	Ash
Heads and intestines of carp and bream, fresh	70.50	6.70	16.85	5.95
The same preserved in sulfuric acid	67.40	7.50	14.05	6.55
Heads of flounder, fresh	74.90	2.10	14.10	5.80
Heads of flounder preserved in acids				
Sulfuric	66.50	3.80	15.63	8.70
Hydrochloric	70.76	3.20	13.88	—
Formic	68.95	4.63	16.38	7.24
Heads and intestines of flounder, fresh	76.20	2.90	13.40	5.10
Heads of flounder preserved in acids				
Sulfuric	68.90	4.22	13.90	8.92
Hydrochloric	73.20	3.76	14.80	5.80
Formic	71.20	4.29	13.70	5.83
Navaga, fresh uneviscerated	77.00	1.30	17.50	2.82
Navaga uneviscerated, preserved in acids				
Sulfuric	—	1.50	20.38	5.22
Hydrochloric	72.54	1.04	—	—
Formic	67.40	4.70	21.19	3.63
Navaga, fresh, eviscerated	74.50	0.55	21.75	4.13
Navaga, eviscerated, preserved in acids				
Sulfuric	64.30	1.10	19.80	5.10
Hydrochloric	69.85	0.80	—	—
Formic	73.70	2.96	24.30	4.73

In order to discover indications of changes in the preserved fish mass, we investigated the consistency, the value of the pH, the total and nonprotein nitrogen contents, as well as the contents of the amino acid nitrogen and the volatile bases.

The investigations indicated that the pH of the preserved mass did not change during storage, but changes in the content of the nonprotein form of nitrogen were dependent on the value of the pH of the mass.

Figure 1 indicates the relation between the pH value and the content of the nonprotein nitrogen in the preserved product stored for 15 days at 20°C.

With the use of sulfuric and hydrochloric acids, the quantity of the nonprotein nitrogen decreased together with the decrease in the pH of the mass. In the case of formic acid, the highest amount of nonprotein nitrogen was observed at a pH level of 4.3 . This confirmed the fermentative character of the protein decomposition during the storage process of formic acid-preserved cattle fodder.

Observations made during the course of several months, concerning the quantity of the nonprotein nitrogen in the preserved product, indicated that its increase generally took place during the initial period of storage, i.e., during the first day, after which it was strongly inhibited. From Figure 2 and Table IX it is evident that in fish offal preserved in sulfuric acid, after 7 days of storage at 20°C, the quantity of the nonprotein nitrogen, in relation to the total nitrogen, increased from 38.0% to 70.7%, in other words—an increase of 32.7%: and, after the following 7 days, only 5.3%. This regularity was observed in all experiments.

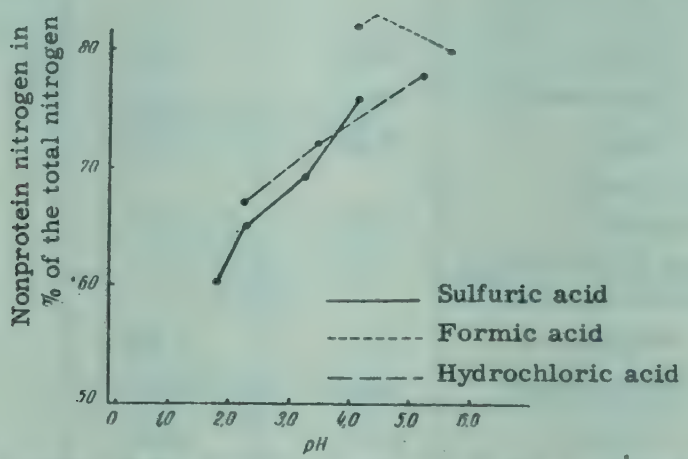

Figure 1. Increase in the quantity of the nonprotein nitrogen in the preserved fish offal as related to the pH, during storage for 15 days at 20°C

Changes of nitrogen forms in fish offal preserved in various acids are recorded in Figures 3, 4 and 5.

The effect of temperature on the decomposition of the protein substances, during preservation of fish offal having different levels of pH, is indicated in Table X.

According to Table X, the protein decomposition took place faster at a temperature of 35°-40°C than at 20°C. Products preserved in formic acid were those most affected by a rise in temperature.

In the process of preserving the raw material, a relationship was observed

between the quantity of nonprotein nitrogen and the consistency of the preserved mass. The greater the amount of nonprotein nitrogen present in the mass, the more liquid it became.

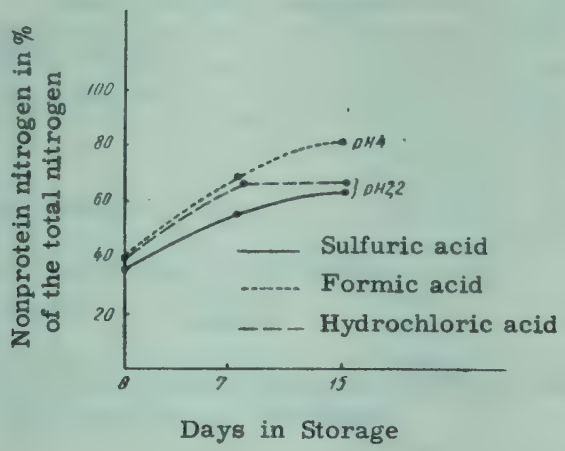

Figure 2. Increase in the quantity of the nonprotein nitrogen in the preserved fish offal as related to the pH, at the beginning of storage at 20°c

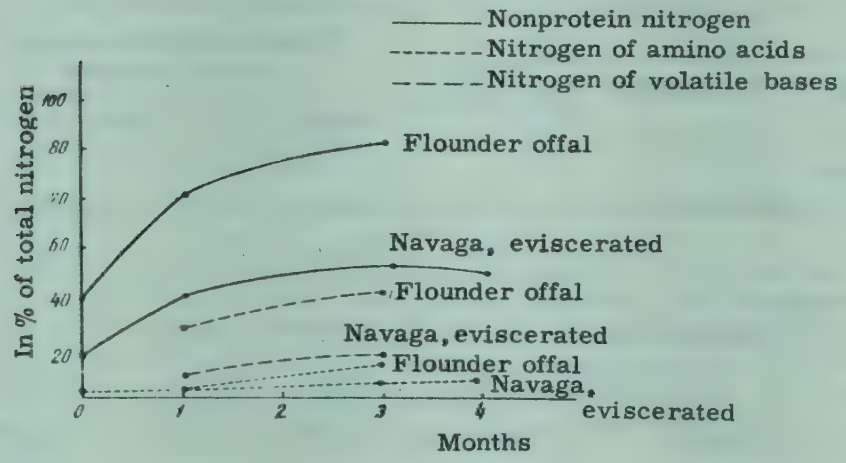

Figure 3. Changes of different forms of nitrogen content during storage of fish offal preserved with hydrochloric acid

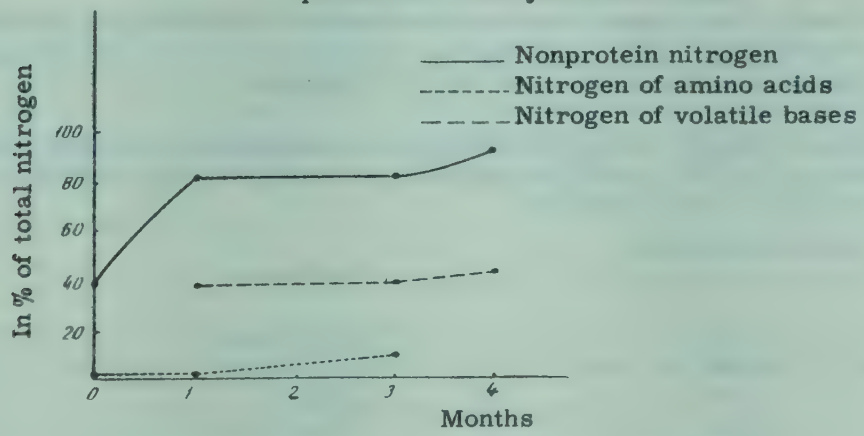

Figure 4. Changes of different forms of nitrogen content during storage of fish offal preserved with formic acid

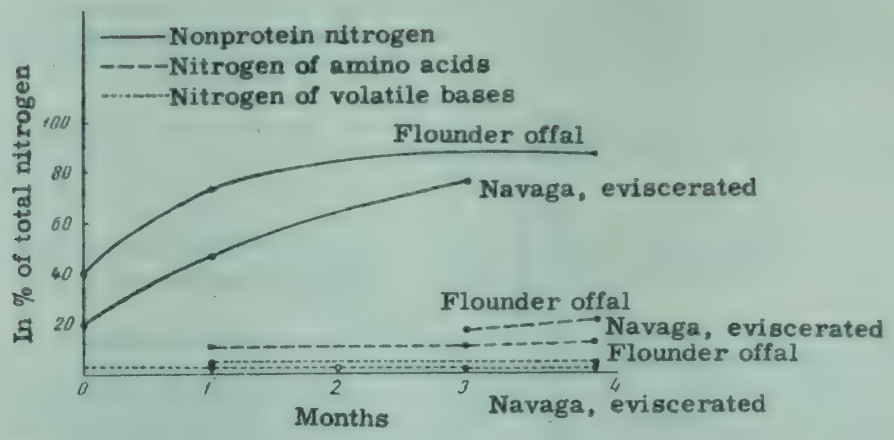

Figure 5. Changes of different forms of nitrogen content during storage of fish offal preserved with sulfuric acid

Table IX

Increase in the quantity of nonprotein nitrogen in preserved offal during storage for 15 days at 20°C

Raw material	Acid used	pH of fish mass	Nonprotein nitrogen in % of total nitrogen		
			Initial	After 7 days	After 15 days
Intestines and roe of pike perch	Sulfuric	4.1	38.0	70.7	76.0
Same	"	2.2	38.0	55.1	64.0
Intestines and heads of pike	Hydrochloric	4.7	42.0	76.3	77.5
Same	"	2.2	42.0	66.3	67.0
"	Formic	4.6	42.0	77.7	80.1
"	"	3.7	42.0	76.8	82.3

The consistency of the minced carp and bream heads and intestines, preserved in sulfuric acid containing 1,100-1,200 mg % of nonprotein nitrogen, was thick, but when the concentration increased to 1,500 mg %, it liquefied.

The relation beween the nonprotein nitrogen content and the consistency of the fish offal preserved in sulfuric acid and stored for 4 months at a temperature of 20° (pH of the mass was 2.1) was as follows:

Nonprotein nitrogen in mg %	Consistency
1,650	Very liquid
1,600	"
1,530	Liquid
1,301	Medium thick
1,260	"
1,100	Thick

Table X

The effect of temperature on decomposition of protein in preserved fish offal

Raw material	Acid used	pH of fish mass	Storage temperature in °C	Nonprotein nitrogen content % of total	
				After 7 days	After 15 days
Intestines and roe of pike perch	Sulfuric	4.1	18-20	70.7	76.0
Same	"	4.1	35-40	75.0	80.8
Same	"	2.2	18-20	55.1	64.0
Same	"	2.2	35-40	62.8	66.4
Intestines and heads of pike	Hydrochloric	4.7	18-20	76.3	77.5
Same	"	3.7	35-40	85.2	—
Same	"	2.2	18-20	66.3	67.0
Same	"	2.2	35-40	69.3	76.8
Same	Formic	4.6	18-20	77.7	80.1
Same	"	4.5	35-40	89.9	—
Same	"	3.7	18-20	76.8	82.3
Same	"	3.9	35-40	90.3	93.5

Changes in Vitamin Content of Acid-preserved Cattle Fodder During Storage

It is well known that the value of cattle fodder is determined not only by the content of protein, fat, and mineral substances, but also by the amount of vitamins present. Eviscerated fish offal contains a large quantity of different vitamins. Especially important in cattle fodder is the vitamin B_{12}, which is one of the factors in protein assimilation. According to Bukin /3/, the addition of 15-20 micrograms of vitamin B_{12} to 1 kg of cattle fodder, increased the assimilation of the protein by 20-30 %.

Vitamin B_{12} is present in all organic tissues, but it is mostly found in the internal organs, especially the liver.

In the liver of some fish (sturgeon, pike perch, and carp) from 1,300-4,800 mcg of vitamin B_{12} were found in 1 kg of dry matter. Considerable quantities of vitamin B_{12} are also contained in the kidneys and the spleen. The internal organs of pike perch, carp, bream, and other fish, contain 1,000 and more mcg of vitamin B_{12} per 1 kg of dry matter.

Analyses were made* of the contents of the vitamins A, B_1, B_2, B_{12}, and D_3, in various types of fish offal before and after preservation. The presence of vitamins A, B_1, and B_2, was investigated by the conventional methods /4/, and that of vitamin B_{12}, by the microbiological method /5/.

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* By E.I. Novikova, a Junior Research Worker of VNIRO

Results of observations of the changes in the quantity of vitamins A, B_1, B_2, D_3, and B_{12} are shown in Table XI. Thus, according to our results, the above-mentioned vitamins were better preserved in formic acid. Hence, after 60 days of storage, the intestines of mintai preserved in sulfuric acid lost 78 % of their vitamin A, 8 % of their B_2, and 15 % of their D_3 contents, while B_1 was fully retained. During preservation in formic acid, the same type of intestines lost 45 % of their vitamin A, 8 % of their vitamin B_2 and 43 % of their vitamin B_{12} contents, while D_3 was fully retained.

It was established that, by boiling the intestines before preservation (see Table XI), 34 % of the vitamin B_{12} content was destroyed.

During storage, however, the boiled, preserved offal retained vitamin B_{12} better than the freshly preserved offal, e.g., freshly preserved sea perch intestines retained 53 % vitamin B_{12} after 5 months of storage, while boiled ones retained 83 %.

Table XI

Changes in vitamin content during acid preservation of fish offal at temperature of 18-20°C

Raw material	Acid used	pH of fish mass	Storage duration in days	Vitamin content in 1 kg of fish mass				
				Integral units		Micrograms		
				A	D_3	B_1	B_2	B_{12}
Intestines of frozen cod (mintai)	—	7.0	—	180,000	150,000	1,100	6,500	150
Intestines of preserved Cod (mintai)*	sulfuric	4.2	20	95,000	120,000	1,050	6,000	—
Same	"	2.4	60	50,000	200,000	1,200	5,900	156
Same	"	4.5	60	40,000	127,000	1,200	6,000	126
Same	formic	4.7	20	126,000	140,000	1,000	5,400	—
Same	"	4.7	60	100,000	196,000	1,200	6,000	84
Intestines of frozen bass	—	6.0	—	2,500,000	950,000	10,500	5,500	565
Intestines of preserved bass	sulfuric	—	30	985,000	537,000	12,500	10,300	—
Same	"	—	150	790,000	552,000	58,000	6,300	300
Intestines of frozen bass	—	5.8	—	2,050,000	770,000	7,700	3,000	372
Intestines of bass, boiled and preserved	sulfuric	—	30	1,550,000	636,000	19,000	11,400	—
Same	"	—	150	1,600,000	1,222	65,000	9,300	310

The Neutralization of Acid-Preserved Cattle Fodder

The value of the pH in cattle fodder used, was usually not less than 4. Therefore, fish and fish offal preserved in sulfuric and hydrochloric acids, and having a pH of 2-2.5, should be neutralized with chalk or lime about one day before

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* See footnote on page 3

feeding to the animals.

In order to determine the quantity of chalk or lime necessary, a number of experiments were made with intestines, and heads of carp and bream preserved in sulfuric acid. The degree of neutralization attained as the result of the addition of various quantities of neutralizers was judged by the value of the pH, and by titration of the acid in the neutralized cattle fodder. Results of the experiments are given in Table XII.

According to these results, lime neutralized the preserved mass better than chalk. By adding 3 % chalk or lime, the neutralized product had the same pH but a different titrable acidity (which was less when using lime).

Table XII

pH and titrated acidity of preserved offal after neutralization (pH of initial product 2.3; titrated acidity 4.85)

Chalk and lime Quantity (in % of weight of the preserved fodder)	pH after neutralization		Titrated acidity (in %) after neutralization	
	with Lime	with Chalk	with Lime	with Chalk
3	4.75	4.75	2.5	2.9
4	4.80	4.90	1.9	2.7
5	4.80	5.00	1.2	2.7

The addition of more than 4 % chalk was not effective because the pH of the titrable acid of the mass hardly changed. Increasing the lime quantity to 4-5 % had a considerable influence on the decrease of the titrable acidity, but a lesser influence on the pH value.

Thus in cases when the pH of fish offal preserved in sulfuric acid was within the limit of 1.7-3.2, it was enough to add 4 % chalk in order to receive in the neutralized mass the pH (larger than 4) required for cattle feeding

pH of preserved mass before neutralization	Chalk addition in %	pH of preserved mass before neutralization
3.2	4	4.3
2.2	4	4.2
1.8	4	4.2
1.7	4	4.2

During the chalk neutralization of the fish cattle fodder preserved in sulfuric acid, a dense foam appeared due to the liberation of carbon dioxide, and the volume of the fodder increased approximately threefold.

After a number of hours, when the carbon dioxide had escaped, the mass resumed its previous size.

The Investigation of the Nutritious Qualities of Fish Offal Preserved in Acids

The feeding qualities of preserved fish and fish offal were investigated by

fattening pigs aged from 2-4 months at the Institute of Cattle Feeding. This was done by the Candidate of Agricultural Sciences S. M. Kabozov, and by the graduate student Yu. S. Shkunkova.

The animals received 650-1,200 g of preserved fish fodder for 2 months. They devoured the food with appetite and no disease was observed during this period. Clinical observations and blood tests showed no irregular changes in the animals.

The weight gain of the pigs which had the preserved fish food included in their feed was as large as that of pigs which had their fodder fortified with ground meat bone and fish meal.

The acid-preserved fodder was administered in quantities equivalent to the content of solid substances in the meal.

At present, investigations on the feeding of preserved fish and fish offal to foxes and mink are being carried out at the Laboratory for the Scientific Research of Fur Farming.

CONCLUSIONS

1. The method of acid preservation can be applied to the preparation of cattle fodder made from various kinds of fish offal and fish of low nutritional value.

Preservation can be achieved by the use of sulfuric, hydrochloric, and formic acids, or their mixtures.

2. Fodder intended for prolonged storage (1/2 year or more) at a temperature of 15-30° should have a low pH, i.e., for preservation in sulfuric and hydrochloric acids, a pH of 2-2.5, and in formic acid, 3.7-4.0 .

For short storage, ($1\frac{1}{2}$ - 2 months) the pH can be higher: for preservation in sulfuric and hydrochloric acids 3.0-3.5, and in formic acid, 4.3-4.5 .

3. The pH of the preserved fish mass depends on the acid quantity, as well as on the mineral substances content of the mass.

4. Of all the acids examined, sulfuric acid had the greatest sterilizing ability during preservation, and hydrochloric acid, the smallest.

5. During storage of the preserved fish fodder, the consistency became less solid as the result of hydrolytic spoilage of the proteins. A decrease in vitamin content also took place, but the amount of vitamins remaining was sufficient to preserve the high nutritional value of the product.

The above-mentioned changes took place within the initial period of storage, during the first 15-20 days, after which they were highly inhibited.

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CHANGES IN THE NITROGENOUS SUBSTANCES OF FISH MEAT DURING MEAL PREPARATION

(Izmenenie azotistykh veshchestv myasa ryby v protsesse prigotovleniya muki)

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Fish meal can be obtained by methods of compression, extraction or combined compression and extraction, depending on the chemical composition of the raw material. Each of these methods necessitates boiling and drying of the fish mass, during which it is subjected to heat influence. During these processes, the protein substances contained in the meat change considerably but the nature and extent of these changes are not sufficiently known.

The purpose of this work is to investigate the protein changes in fish meat and its amino acid composition during the process of fish meal preparation.

Methods of Investigation

The investigations were carried out on frozen pike perch stored in the refrigerator for 3-6 months.

Pike perch has lean meat and was chosen in order to avoid any possible influence of fat on the protein changes; furthermore, to avoid any possible influence of mineral substances, the experiments were carried out on muscle tissue without skin and bones.

The meal was prepared from muscle tissue of pike perch under laboratory conditions by the following method: pike perch meat without skin and bones was minced in a mincing machine and boiled vigorously in a covered vessel for 50 minutes, 20 minutes of which consisted in heating up to the boiling point; and the remaining time in the actual boiling itself at 98—100°C. The boiled mass was wrapped in a cloth and pressed in a hand oil press at a pressure of 10 kg/cm^2. The liquid obtained by compression was carefully collected. The press cake was dried in a special drying apparatus and the following methods of drying were applied:

1) At 70-90° C for 7½ hours;
2) At 70-80° C with air blown through the drying apparatus for 1½ hours;
3) Under vacuum at a residual air pressure of 65 mm of Hg at a temperature of 30-40° C for 2 hours;
4) At 130-140° C for 30 minutes.

The weight of the raw material, of the semi-prepared products obtained during the various stages of the process, and of the prepared meal was carefully calculated and chemically investigated.

In order to determine the general features of the raw material, semi-prepared products, and finished meal, the moisture, total nitrogen, fat and mineral substances (ash) were investigated by applying the conventional methods.

In order to assess the nitrogen changes in fish tissue during the process of meal preparation, investigations were carried out on the ratio of protein to nonprotein nitrogenous substances, on the contents of water-soluble and salt-soluble proteins, and on the amino acid composition of proteins in the raw material, semi-prepared products, and the finished meal.

The general content of protein nitrogen in various samples was determined according to the Barnshtein method, and the quantity of nonprotein nitrogen was calculated according to the difference between the total and protein nitrogen. In order to determine the quantity of water-soluble and salt-soluble proteins, the material examined was subjected to water extraction and 7% salt-solution extraction respectively, following the method used by Shapiro and Karpov in their investigations on the protein content of muscle tissue of fresh pike perch /11/. We only modified the duration and number of extractions to obtain full extraction of proteins.

The nitrogen content of water-soluble proteins (albumins) was determined by the difference between the total and nonprotein nitrogen extracted by water, and the nitrogen content of salt-soluble proteins (globulins), according to the difference between the total nitrogen extracted by salt and that extracted by water. The nitrogen of the remaining proteins was determined by combustion of the material remaining after extraction of salt-soluble nitrogen substances.

In order to determine the amino acid composition of proteins, the samples of this material were first treated with alcohol and ether in order to remove fat and moisture. Dry and fat-free proteins were hydrolyzed by boiling, with 20 times the volume of 20% hydrochloric acid, for 25 hours at a temperature of 130-140°C. According to our experience such a method of hydrolysis results in a complete cleavage of proteins to amino acids and reduces deamination.

The product obtained by hydrolysis was investigated by the Van Slyke method /11 and 12/ with the Cavet and Plimmer modification. The total nitrogen and amino nitrogen of monoamino acids and diamino acids, the nitrogen of volatile bases and humins and also the nitrogen of individual diamino acids, lysine, arginine and histidine, was determined. Calculations of the quantity of the above-mentioned forms of nitrogen were carried out by the semi-micro methods, using the Parnas apparatus for nitrogen determination /1/ and the apparatus of Tsuverkalov for gasometric determination of α amino acids /10/.

Features of Fish Meal Production

In Table I the chemical composition of the raw material, of the semi-prepared product, and of the finished meal are given. The results were obtained in our experiments on the processing of meal from pike perch meat.

The meat weight decreases slightly upon boiling (from 0.9-5.8%), due to evaporation. After pressing the boiled meat we obtained 57.7-59.3% of the weight of the fresh fish meat. The output of finished meal after drying by 1, 2, and 3 different methods were all very similar, yielding a proportion of 21.6-21.9% absolutely dry meal to the weight of fresh fish meat. After drying according to the fourth method, i.e., at the highest temperature of 130-140°C, the output of absolutely dry meal was less, i.e., 19.5%.

The types of meal obtained by various methods of drying differed in their organoleptic features and chemical composition. The color of meal dried under vacuum at a temperature of 30-40° C (the 3rd method) was yellow and friable. The taste and smell were normal.

Table I

Designation	Output (in % of raw material weight)	Chemical composition in %				
		Moisture	Total nitrogen (N)	Protein (N × 6.25)	Fat	Ash
Experiment I						
Raw material - pike perch meat.....	100	78.93	3.14	19.62	0.66	1.06
Boiled mass	94.2	77.67	3.28	20.50	0.71	1.11
Press cake	59.3	68.06	4.77	29.81	1.05	1.21
Expressed juice (broth)...	34.9*	91.86	0.97	6.06	0.14	1.36
Meal (1st drying method)..	20.2	7.06	13.70	85.62	3.07	3.52
Experiment II						
Raw material - pike perch meat	100	80.03	3.03	18.94	0.45	1.08
Boiled mass	99.1	79.97	3.03	18.94	0.45	1.08
Pressed mass	57.7	68.49	4.79	29.93	0.73	1.35
Expressed juice (broth) ...	41.4*	94.78	0.67	4.19	0.08	0.93
Meal prepared when various drying methods were applied:						
2nd	19.8	8.27	13.77	86.06	2.12	3.89
3rd	20.0	8.68	13.90	86.88	Not Certain	3.99
4th	18.5	5.35	14.19	88.68		4.10

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* The output of broth was calculated as a difference between the weight of the pressed and boiled mass.

The meal dried at 70-80° C in the drying apparatus for 1.5 hours with fairly intensive aeration (2nd method) had a darker color but showed no other clear difference from the meal dried in vacuum.

The meal samples dried at a temperature of 70-90° C for 7.5 hours, and at 130-140° C for 0.5 hours without aeration (methods 1 and 4), was brown and had the taste and smell of broiled fish. The sample dried at a temperature of 70-90° C not only had a friable consistency but was crunchy when chewed, and the sample dried at 130-140° C contained coagulated pieces of the fish mass.

The protein content (N × 6.25) in different meal specimens in percent of absolute dry substance was:

Drying under vacuum at 30-40°C..... for 2 hours..... 95.12;
Drying under atmospheric pressure:

at 70-80°C ..... for 1.5 hours..... 93.81;
at 70-90°C ..... for 7.5 hours.....92.13;
at 130-140°C ..... for 0.5 hours.....93.68.

Thus, according to these data, by increasing the temperature of by prolonging the duration of drying, the quality of meal deteriorates and the protein content decreases.

According to the weights and chemical analyses of raw material, semi-prepared products, and finished meal, we made a diagram of the process of meal preparation. The moisture, organic (nitrogen and fat), and mineral substances contained in the semi-prepared product and the meal were calculated in percent of their content in the raw material, and of the whole weight of the raw material. The results are recorded in Table II.

Table II

Designation	In % of weight of raw material			In % of initial content in raw material			
	Moisture	Organic substances	Mineral substances	Moisture	Organic substances: Total	Organic substances: Including Protein (N × 6.25)	Mineral substances
Experiment I							
Raw material - pike perch meat	78.9	20.0	1.0	100.0	100.0	100.0	100.0
Boiled mass	73.2	19.9	1.0	92.7	99.5	97.8	99.5
Press cake	40.4	18.3	0.7	51.2	91.2	90.2	67.7
Expressed juice (broth)	32.0	1.7	0.5	41.5	8.3	7.6	31.7
Meal (1st drying method)	1.4	18.1	0.7	1.8	90.6	88.4	67.4
Experiment II							
Raw material - pike perch meat	80.0	18.9	1.1	100	100.0	100.0	100.0
Boiled mass	79.2	18.8	1.1	99.1	99.5	98.4	99.9
Press cake	49.6	17.4	0.8	49.4	92.2	91.3	72.2
Expressed juice (broth)	39.2	1.6	0.4	49.7	7.3	7.1	27.7
Meal prepared when various drying methods were applied:							
2nd	1.6	17.3	0.8	2.0	92.2	90.0	71.6
3rd	1.8	17.4	0.8	2.2	92.2	91.1	72.2
4th	1.0	16.7	0.8	1.2	88.6	86.5	70.1

The data in Table II indicate that during the process of meal preparation the pike perch loses, 9.0 - 13.5% of nitrogenous substances, 32% mineral substances and 88% of the moisture content of the initial raw material.

As a result of heat treatment, the meat loses about 2% of nitrogenous substances upon boiling, and from 0.2 to 4.7% upon drying, depending on which drying method is used. The loss of nitrogenous substances upon drying increases with increase in temperature and duration of the process. In the case of drying under vacuum at a temperature of 30-40°C (3rd method), there is almost no loss of nitrogenous substances (0.2%). Drying at a normal atmospheric pressure at 70-90°C for 1.5-7.5 hours (methods 1 and 2) was accompanied by a loss of 1.3-1.8% of nitrogenous substances. Increasing the drying temperature up to 130–140°C with simultaneous reduction of time of duration to 30 minutes (4th method) led to further loss in nitrogenous substances to 4.7%.

By pressing the boiled meat we extracted the broth which contained 7–7.5% of nitrogenous substances. Thus the loss of nitrogenous substances in the broth was from 53% to 80% of the total nitrogenous substances lost during preparation of the meal, depending on which method of drying was used.

The loss of mineral substances takes place only during the actual pressing. These are the water-soluble substances which are removed with the broth.

The dehydration of the protein mass during the process of meal preparation has two stages:

1) during boiling of raw material and subsequent pressing of boiled mass for extraction of broth;

2) during drying of pressed mass.

The quantity of water removed in both stages was approximately the same (52-46%).

Changes in Protein and Nonprotein Nitrogenous Substances.

The protein and nonprotein nitrogen contents of the raw material, the semi-prepared product, and the finished meal are given in Table III. The data recorded permit us to form an opinion as to the extent of breakdown of proteins in fish–meat during the process of preparation of meal.

During the process of meal preparation a considerable decrease in true protein substances and an increase in the quantity of nonprotein nitrogenous substances take place. Thus, if in the fresh muscle tissue 96-97% of the total quantity of nitrogen were protein nitrogen, and the rest were nonprotein nitrogen, in the finished product we obtain another result, i.e., 85-91% protein nitrogen and 9-15% nonprotein nitrogen (calculated as percentage of the total nitrogen content of meal).

The variations in ratio of protein to nonprotein nitrogenous substances were noted at each stage of the process of meal preparation. During boiling and drying the changes were caused by thermal influence, and during pressing, by the mechanical extraction of part of the nitrogenous substances into the broth.

The protein nitrogen lost during boiling exceeded the nonprotein increase for the following reason. During boiling, a small amount of volatile substances appeared in which approximately 2% of total nitrogenous substances were lost.

Table III

Designation	Protein nitrogen	Nonprotein nitrogen	Total nitrogen	Protein nitrogen	Nonprotein nitrogen
	In % of total nitrogen in sample		In % of total nitrogen of initial raw material		
Experiment I					
Raw material - pike perch meat..	96.8	3.2	100	96.8	3.2
Boiled mass	94.2	5.8	97.8	92.1	5.7
Pressed cake	95.0	5.0	90.2	85.7	4.5
Meal (1st drying method)	84.9	15.1	88.4	75.1	13.3
Experiment II					
Raw material - pike perch meat ..	95.7	4.3	100	95.7	4.3
Boiled cake	94.2	5.8	98.4	92.7	5.7
Pressed mass	9	5,0	91.3	86.7	4.6
Meal (2nd drying method)	91.1	8.9	90.0	82.0	8.0

The extent of protein breakdown during drying depends on the drying method. When drying the protein mass for 7 1/2 hours at 70-90°C (the first method) it loses 10.5% of protein nitrogen and simultaneously the nonprotein nitrogen increases by 8.8%.

When drying at 70-80°C for 1 1/2 hours (2nd method) the loss of protein nitrogen was only 4.7%, and the increase in nonprotein nitrogen, 3.4% (in % of the total nitrogen content of the raw material). The loss of 1.5% of total nitrogen which takes place during drying can be ascribed to the evaporation of volatile nitrogenous substances.

As a result of pressing we lose 7.0–7.5% of the total original nitrogen content. Approximately 85% of nitrogenous substances in the broth are proteins, and 15% nonprotein substances.

Changes in Water–soluble and Salt–soluble Proteins

In order to determine the extent of heat denaturation of proteins during meal preparation we observed the changes in protein solubility in water and in 7% salt solution at each stage of the technological process. The results are recorded in Table IV.

According to the data recorded in Table IV the water-and salt-soluble proteins of the albumin and globulin types, which are approximately 55% of all protein substances of the muscle tissue of frozen pike perch, were almost completely denatured during the process of meal preparation. The denaturation of the proteins mentioned generally takes place at the first stage of heat treatment of fish, i.e., during boiling. Hence, the globulins change more than the albumins. This is proven by

the fact that, after boiling, the albumin content is 30%, and that of globulins, only 5% of their initial content in raw material. The quantity of proteins insoluble either in water or in salt solution increases by 1.6 - 2 times after boiling.

Pressing of the boiled fish mass led to extraction into the broth of soluble nitrogenous substances, generally proteins of the albumin type (6.4% of the total nitrogen content of raw material), as well as a small quantity of nonprotein substances (approximately 1% of the total nitrogen content of the raw material). On the average 2/3 of the total water-soluble proteins present in the boiled fish mass pass into the broth. The globulin content of the press cake after pressing remained unchanged.

During drying of the press cake, denaturation of proteins (albumins and globulins) takes place. Simultaneously, a slight decrease in the residual protein content is observed. In the finished meal the albumin and globulin contents are only 1-1.5% of their initial content in the raw material.

The comparison of results of observations on changes in different protein fractions with those on changes in general protein and nonprotein nitrogen leads us to presume that the protein denaturation of fish meat during the process of meal preparation, which is the result of heating fish up to 100°, is accompanied by a partial breakdown of proteins, thus giving a number of nonprotein nitrogenous substances including volatile bases.

Thus, the increase in the quantity of nonprotein nitrogenous substances, which is approximately 1.5-2 times during the first stage of heat treatment (boiling), is caused by a partial breakdown of albumins and globulins. In the second stage (drying), the increase in the quantity of nonprotein nitrogen is caused by the decomposition of insoluble proteins. The increase is approximately two to threefold.

The nitrogen of volatile bases, formed during the breakdown of proteins, is lost during boiling and drying.

The results of our investigations on protein changes in fish meat during heating in the process of preparation of meal agree in principle with the results obtained by other scientists on the decomposition of fish protein during heating (2, 4, 5, 6, 7).

Changes in the Amino Acid Contents of Proteins

We investigated protein preparations obtained during the process of meal preparation. These preparations were obtained by taking two samples from experimental boiling and pressing of fish meat from experiments carried out by boiling and pressing under identical conditions, and four samples from experiments carried out on drying of the press cake according to different methods. The results of our experiments are recorded in Table V.

The data recorded therein indicate that, after the boiling of meat and drying the boiled mass under vacuum at 30-40°C (3rd method), the relative contents of the different forms of nitrogen showed practically no change at all. But the drying of the boiled mass under atmospheric pressure, using all the other methods of drying (1st, 2nd and 4th methods), leads to a decrease in the relative quantities of total nitrogen and mono- and diamino acid nitrogen, and a corresponding increase in the nitrogen of volatile bases takes place.

In connection with the individual diamino acids, it should be emphasized that the protein of the finished meal contains less nitrogen from lysine (including the cystine fraction) and arginine and much more (2-3 times as much) nitrogen from histidine, than do the proteins of fresh pike perch flesh.

Table IV

Designation of samples	Total nitrogen in %	Water-soluble fractions		Salt-soluble fractions		Nitrogen of proteins not soluble in water and in NaCl	Water-soluble fractions		Salt-soluble fractions	
		Total nitrogen	Protein nitrogen	Total nitrogen	Nitrogen of globulins		Total nitrogen	Protein nitrogen	Total nitrogen	Nitrogen of globulins
		In % of total raw material nitrogen					In % of content of corresponding nitrogen fractions in raw material			
Experiment I										
Raw material - pike perch meat	100.0	31.5	28.3	47.8	16.2	51.0	100.0	100,0	100.0	100.0
Mass after boiling (with broth)	97.8	4.97	9.3	15.8	0.8	81.3	47.5	32,7	33.0	4.7
Pressed cake	90.2	7.4	2.8	8.2	0.8	81.3	23.4	10,0	17.1	4.7
Meal (1st drying method)	88.4	13.6	0.3	13.9	0.3	74.2	43.2	1,1	29.0	1.6
Experiment II										
Raw material - pike perch meat	100.0	32.4	28.1	61.0	28.7	39.6	100.0	100,0	100.0	100.0
Mass after boiling (with broth)	98.4	14.7	8.8	15.6	0.9	82.7	45.4	31,3	25.6	3.3
Pressed cake	91.3	7.6	2.8	8.5	0.9	82.7	23.4	10,1	13.9	3.3
Meal (2nd drying method)	90.0	8.6	0.5	8.8	0.2	80.9	26.5	1,6	14.3	0.7

Table V

Nitrogen	Content of different nitrogen forms in % of total nitrogen							
	Experiment I			Experiment II				
	Raw-material pike perch meat	Boiled mass	Meal (1st drying method)	Raw-material pike perch meat	Boiled mass	Meal		
						2nd drying method	3rd drying method	4th drying method
Volatile bases	10.5	11.0	18.0	10.9	11.4	13.7	12.6	17.9
Humic substances	3.0	3.0	6.0	3.5	2.1	3.7	1.5	4.8
Monoamino acids total	63.3	62.1	54.4	62.9	60.8	58.6	60.6	58.8
" aminic ...	62.5	62.0	54.2	61.1	60.8	58.3	60.7	58.5
Diamino acids total	26.7	26.8	24.6	27.9	28.1	26.8	28.3	25.9
" aminic	17.0	16.3	14.7	17.9	17.8	16.3	17.8	15.9
Lysine (including the cystine fraction).....	13.7	12.8	11.0	14.5	14.1	12.5	14.1	12.2
Arginine	11.9	11.6	10.6	12.2	12.0	11.7	11.9	10.7
Histidine	1.0	2.3	3.0	1.2	2.0	2.7	2.3	2.0

Table VI

Designation	In % of total protein nitrogen substances of initial raw material									
	Total nitrogen	Nitrogen of volatile bases	Nitrogen of humic substances	Mono-aminoacid nitrogen		Diaminoacid nitrogen		Lysine nitrogen (including the cystine fraction)	Arginine nitrogen	Histidine nitrogen
				Total	Aminic	Total	Aminic			
Experiment I										
Raw material -- pike perch meat	100	10.5	3.0	63.3	62.5	26.7	17.0	13.7	12.0	1.1
Boiled mass	97.8	11.2	3.0	60.2	60.0	25.9	16.2	12.8	11.0	2.0
Loss or increase during boiling process	−2.2	+0.7	−0.1	−3.1	−2.5	−0.8	−0.8	−0.9	−1.0	+0.9
Pressed mass	90.2	9.9	2.7	55.5	55.3	23.9	14.7	11.5	10.4	2.0
Loss during pressing (goes into broth)	−7.6	−1.3	−0.3	- 4.7	−4.7	−2.0	−1.5	−1.3	−0.6	-
Meal (1st drying method)	88.4	16.0	5.3	46.9	46.7	21.2	12,6,	9.5	9.1	2.6
Loss or increase during drying process	−1.8	+6.10	+2.6	−8.6	−8.6	−2.7	−2.1	- 2.0	−1.3	+0.6
Total losses or increases during the meal preparation process by using the 1st drying method	−11.6	+5.5	+2.2	−16.4	−15.8	−5.5	−4.4	−4,2	−2.9	+1.5
Experiment II										
Raw material -- pike perch meat	100	10.9	3.5	62.9	61.1	27.9	17.9	14.5	12.2	1.2
Boiled mass	98.4	11.1	2.0	59.4	59.5	27.3	17.5	13.9	11.6	1.8
Loss or increase during boiling process	−1.6	+0.2	−1.5	−3.5	−1.6	−0.6	−0.4	−0.6	−0.6	+0.6
Pressed mass	91.3	10.3	1.9	55.0	55.0	25.4	16.1	12.7	10.9	1.8
Losses during pressing (goes into broth)	−7.1	−0.8	−0.1	−4.4	−4.5	−1.9	−1.4	−1.2	−0.7	−
Meal (2nd drying method	90.0	12.3	3.4	51.5	51.2	23.6	14.3	11.0	10.2	2.4
Meal (3rd drying method)	91.1	11.2	1.3	54.0	54.1	25.2	15.9	12.6	10.6	2.1
Meal (4th drying method)	86.6	14.8	4.0	48.7	49.3	21.5	13.2	10.1	8.9	2.5
Loss or increase during the process of different drying methods:										
2nd	−1.3	+2.0	+1.5	−3.5	−3.8	−1.8	−1.8.	−1.7	−0.7	+0.6
3rd	−0.2	+0.9	−0.6	−1.0	−0.9	- 0,2	−0.2	−0,1	−0.3	+0.3
4th	−4.7	+4.5	+2.1	−6,3	−5.7	−3.9	−2.9	−2.6	−2,0	+1.3
Total losses or increase during meal preparations process, using drying methods:										
2	−10.0	+1.4	−0,1	−11.4	−9.9	−4.3	−3.6	−3.5	−2.0	+1.2
3	−8.9	+0.3	−2.2	−8.9	- 7.0	−2,7	−2.0	−1.9	−1.(	+0.9
4	−13.4	+3.9	+0.5	−14.2	−11.8	−6.4	- 4.7	−4.4	−3.3	+0.7

Table VII

No of experiment		In % of total protein nitrogen substances of expressed juice							
	Nitrogen of volatile bases	Nitrogen of humic substances	Nitrogen of aminoacids		Nitrogen of diaminoacids		Lysine nitrogen (including the cystine fraction)	Arginine nitrogen	Histidine nitrogen
			Total	Aminic	Total	Aminic			
1	17.3	3.7	61.0	60.4	25.6	19.3	17.2	8.3	0.1
2	12.4	2.1	63.3	63.6	28.0	20.8	18.1	8.9	0.3

In order to demonstrate the quantitative changes in the composition of the proteins upon processing, the balance of the different nitrogen forms is recorded in Table VI. The changes in protein amino acid contents at each stage of the process are recorded in Figures 1, 2 and 3. In Table IV the amino acid content of meal obtained by different methods of drying is also recorded.

According to Table VI, the amino acid contents of fish meat change considerably in the process of meal preparation due: (1) to the partial destruction of amino acids by heat treatment in the boiling and drying processes and (2) to the loss of amino acids together with other nitrogenous substances in the extracted broth. By boiling and drying 6 to 18.5% were lost and, during compression, approximately 7% of the total amino acid nitrogen contained in the raw material. Thus, the total amino acid nitrogen lost during the process of preparation was 13-25.5%.

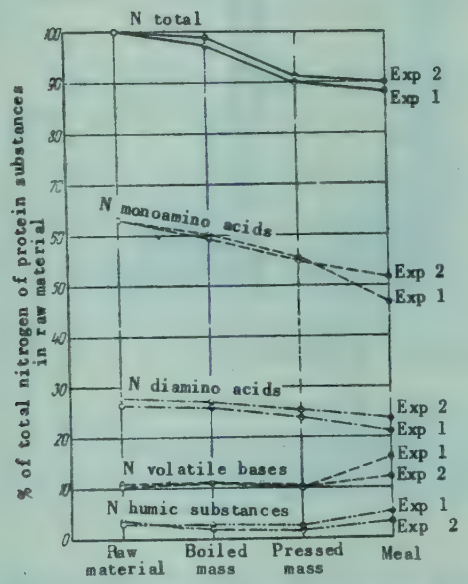

Figure 1. Quantitatives changes of the basic nitrogen forms of protein substances in the different stages of meal preparation

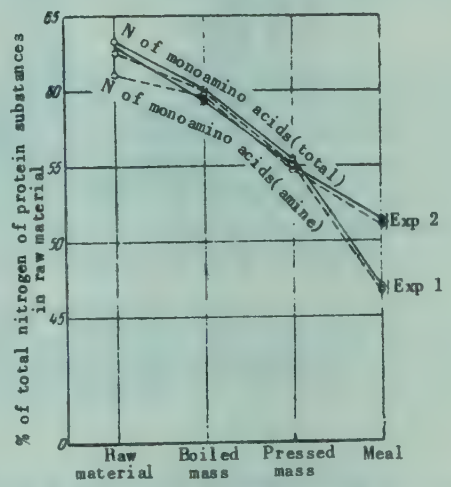

Figure 2. Quantitative nitrogen in monoamino acids in the process of meal preparation

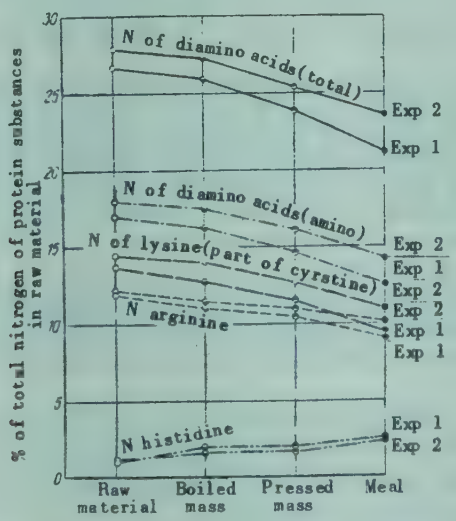

Figure 3. Quantitative nitrogen changes in diamino acids in the process of meal preparation

During the heat treatment of fish meat the mono and diamino acids were destroyed. During boiling greater losses were registered in monoamino acids, the amide groups were completely split off, and the quantitative difference between the total and amino nitrogen of monoamino acids disappeared. The monoamino acid nitrogen lost during boiling was on the average 5%, and the diamino acids lost 2.5% respectively of their initial content in the raw material. During drying a more extensive decomposition of mono and diamino acids was noted than during boiling, and the extent of decomposition depended on the drying method used.

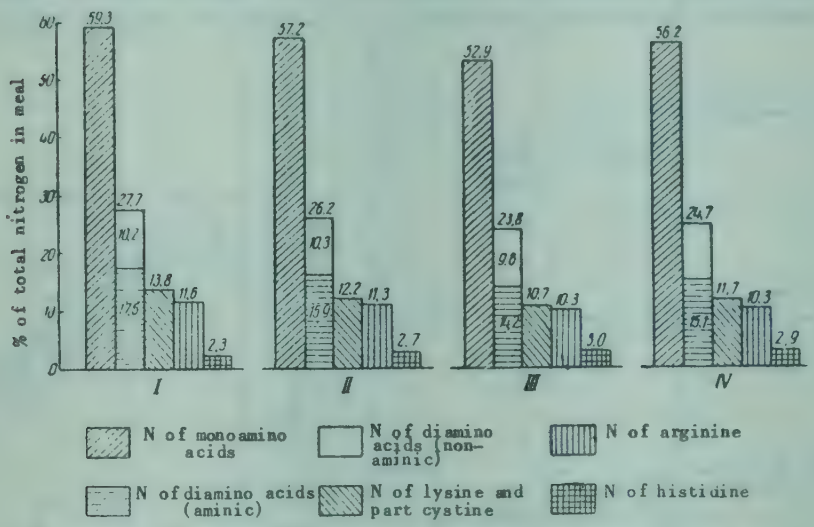

Figure 4. The ratio between mono and diamino acids in meal dried by different methods

The nitrogen of mono- and diamino acids lost by increasing the temperature to 130-140°C (4th method) was 15%. Similar results were obtained by drying at a temperature of 70-90°C for 7 1/2 hours (1st method). By cutting down the drying time to 1 1/2 hours (2nd method) under the same temperature conditions, the loss of mono-and diamino acid nitrogen was reduced to 7%. In the case of vacuum drying at a temperature of 30-40°C (3rd method) there was almost no destruction of the diamino acids, and there was only a loss of 1.8% of the monoamino acids.

Observations made on the individual diamino acids indicated that, during boiling and drying, a partial destruction of lysine and arginine takes place. Thus, 4-6% of lysine nitrogen and 5.5-8% of arginine nitrogen were lost during boiling. During drying, from 1 to 20% of lysine nitrogen and from 2.8 to 18% of arginine nitrogen were lost, depending on the drying method employed. The lowest nitrogen losses of the above-mentioned diamino acids were registered in the case of vacuum drying at a temperature of 30-40°C (3rd method), and the highest, in the case of the usual drying, at 130-140°C (4th method). The increase in the histidine content during the processes of boiling and drying tallies with the results obtained by other scientists on investigations of processes of heat denaturation of protein (8, 15).

The breakdown of amino acids during boiling and drying is accompanied by the formation of more simple volatile nitrogenous bases (0.9-6.1% of the total nitrogen content of the raw material), and by the formation of humins (2.6% of the total nitrogen content of the raw material).

The quantity of humin nitrogen was dependent on the method of heat treatment and was higher in those cases where the protein mass was exposed to more intensive or prolonged heat influence (1st and 4th drying methods). This leads us to suppose that the humins are formed, not only as a result of condensation of amino-acids which are unstable during acid hydrolysis, i.e., tryptophan and oxyamino acids /9/, but also during condensation of other amino acids which were destroyed during the protein mass treatment /3/.

It is interesting to evaluate the amino acid content of protein substances which passed into the broth during pressing (Table VII).

Table VII indicates that the proteins of the broth are very similar to the proteins of fresh and boiled meat in their total mono- and diamino acid nitrogen content (Table V). Diamino acids in broth are generally represented by lysine (with part of cystine) and arginine. Histidine is found in protein substances in very small quantities.

The results of our investigations on broth can be compared with those obtained by other scientists.

Thus, Pottinger /16/ noted that during boiling of protein substances, such amino acids as tyrosine, tryptophan, and cystine did not pass into the broth and therefore, the presence of the above-mentioned substances in meal prepared from fresh meat is relatively less than in that prepared from boiled meat. According to the investigations of Deas and Tarr /13, 14/ the liquid obtained by pressing contains all the amino acids characteristic of fish proteins. They also obtained vitamins of the B-group (thiamine, riboflavin, nicotinic acid, choline and vitamin B_{12}).

The data given indicated that the nitrogenous substances contained in broth are of great value and should be utilized in order to reduce the protein loss during fish meal preparation.

CONCLUSIONS

1. In the process of fish meal preparation carried out according to the technological methods generally accepted in the industry, a considerable change in, and partial loss of nitrogenous substances takes place.

2. During heat treatment in the boiling and drying processes, denaturation and coagulation of soluble proteins take place, leading to a loss of the lyophilic properties and to a partial breakdown of proteins. This is accompanied by the formation of simpler nonprotein nitrogenous substances and volatile nitrogen compounds. There are also changes in the amino acid composition of the protein substances. The above-mentioned protein changes depend to a considerable extent on the method of drying employed.

3. The nitrogenous substances lost during the preparation of fish meal are 9.0-13.5% of the total nitrogen contained in raw material depending on the drying method employed. The losses are the result of:

a) formation and extraction of volatile nitrogenous compounds during breakdown of proteins during boiling and drying of the fish mass (from 2.0–6.5% of total nitrogen content of raw material);
b) mechanical separation of a part of the soluble nitrogenous substances into broth during pressing of boiled fish mass (approximately 7% of total nitrogen content of raw material).

5. It is possible to carry out the boiling, drying and evaporation in one apparatus.

The combination of these procedures in one apparatus will enable us to avoid losses in the semi-prepared product and will also improve the hygienic conditions of the process.

In order to effect the proposed technological methods of fish meal preparation, an apparatus should be used which would divide the whole process into two phases:

First phase: boiling of fish mass by a dry method (without intense steam application) under pressure;

Second phase: evaporation and drying of boiled mass under vacuum.

A Laabs kettle can be used as such an apparatus.

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THE INFLUENCE OF INTENSITY PROTEOLYSIS AND MICROBIAL CONTAMINATION ON THE APPEARANCE OF "SPLITTING" IN VARIOUS TYPES OF FISH

(Vliyanie intensivnosti proteoliza i obsemenennosti mikrobami na obrazovanie "lopantsa" u nekotorykh vidov ryb)

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The quality and commercial value of fish products depend on the quality of the raw material used.

The appearance of "splitting" (abdominal damage) observed in different kinds of fish, especially small fish which are susceptible to spoiling during storage (sardine, sprat, anchovy, bullhead), indicated a deterioration in the quality of the raw materials.

The cause of "splitting" is not well known, and the question of the nutritious quality of the split fish has not been studied at all.

Practice has shown that catching methods and transport conditions (transport duration, temperature, thickness of the fish layer) have a great influence on the occurrence of "splitting". Observations made on the nature of the "splitting" lead us to suppose that this phenomenon is caused by specific bio-and physico-chemical reactions which take place in the dead fish after the destruction of their regulatory systems. These factors render the fish body more easily penetrable to microorganisms. The growth of the microorganisms in fish tissue hasten its disintegration because of the microbial enzymes added to the action of the body enzymes.

Hence, the complex factors causing the "splitting" became more complicated during storage. Therefore, when investigating the problem of "splitting", we took into account both the external factors such as temperature, storage duration, and the thickness of the fish layer, as well as the bacterial contamination and the intensity of proteolysis which took place in the fish tissue after catching.

Investigations were carried out on three types of fish: 1) Azov sardine caught in Spring (May), 2) anchovy-like sprats caught in Summer (August), and 3) Azov anchovy caught in Autumn (November).

In the Zhdanov and Kerch Fish Combines and the Makhachkala Refrigerating Enterprise, the number of "split" fish in different fish batches was determined before and after shipping. The effect of storage and temperature conditions and the thickness of the fish layer on the speed of "splitting," the development of microflora and the intensity of proteolysis were also investigated in the laboratories. The fish were arranged in three layers separated from each other by nets, and stored under laboratory conditions in wooden boxes 30 × 45 × 65 cm.

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*["Little sardine", tiulka (Clupeonella d. delicatula), translated throughout this article as "sardine"].

Results of Observations

Sardines and anchovy were transported from the fishing places to the fish combines 1-2.5 hours after catching, and were unloaded by means of a fish pump. Air temperature was from 15 to 18°C.

The anchovy-like sprats caught at a depth of 20 to 22 m were transported in a chilled state in zinc-coated containers. After unloading the fish were placed in wooden boxes in which they were then transported in refrigerated trucks to the Refrigeration Plant. An interval of from 1.5 to 2 hours elapsed between unloading and placing in the refrigerator, and the fish came into contact with an air temperature of from 25 to 30°C.

All the fish brought in by the ships were in good condition. They were in a rigid state but their consistency was resilient, and their surfaces shiny.

The number of "split" fish in sardine samples taken before unloading was from 3.0 to 10.3%, but after unloading with the fish pump the number reached 9.8 to 31.6%, and was probably caused by mechanical damage. In anchovy samples there was no "splitting" at all, but after fish pumping the number of "split" fish reached 19.8%.

Temperature also had a considerable influence on the occurrence of "splitting". In practice the quick chilling after catching prevented the occurrence of "splitting" in the sprats while on the ship. A check of sprat samples taken before refrigeration and after they had been warmed during unloading and transport to the refrigerating factory showed 42% "splitting".

The high air temperature caused a rapid lessening of the rigidity and a softening of the tissue which made the fish easily damageable under the influence of the external contacts.

Results of our observations on the occurrence of "splitting" in fish stored in wooden boxes are recorded in Table I.

Table I

Type of fish	Storage temperature in °C	Duration of storage in hours	Quantity of "split" in different layers of fish in the box, in %			
			Upper layer	Middle layer	Bottom layer	Average
Sardines[1]	20	12	14.7	32.4	36.7	28.0
	0 - 1[3]	48	8.6	13.0	5.8	9.6
	0—1	96	12.9	19.4	23.5	18.4
Anchovy[2]	0—2[3]	48	47.7	50.9	56.2	50.8
	0—2	72	59.0	55.0	61.8	58.6
	0 - 2	96	68.7	57.1	69.9	65.5

1) Height of lower and middle fish layers in the boxes was 25 cm and together weighed 20 kgs. The height of the upper layer was 10 cm and weighed 5 kg.
2) The weight of the middle and lower layers equaled 10 kg, the upper--15 kg.
3) Before placing in boxes, the fish were chilled.

The results indicate that the temperature, storage duration, and thickness of the fish layer considerably influenced the occurrence of "splitting". With the increase in temperature, storage duration, and thickness of the fish layer, the number of "split" fish also increased. In the lower layers the quantity of "split" fish was larger than in the upper ones.

It should be noted that the character of the "split" fish caused by mechanical damage differed from that of the "split" caused during storage. In the former case, the "splitting" occurred in the abdominal region at the place where the scales came into contact with the ribs. In the latter case "splitting" had the nature of tissue perforation near the head on the abdominal side, and the consistency of the fish became softer. This indicated that the tissue perforation was caused by biochemical changes which took place in the fish tissue during storage.

Microbiological investigations

Samples of anchovies and sprats were taken for purposes of microbiological investigation during the storage in boxes. Three fish were taken from each layer and together were used as an average sample.

Sprat samples were taken in order to observe the quality of the fish on the ship as well as after transport to the refrigeration plant.

The sardine and sprat samples were examined immediately, but anchovy samples were frozen and sent from Zhdanov to Rostov-on-Don.

The bacterial contamination of the muscle surfaces and fish intestines was determined according to accepted methods /1, 2/.

In order to ascertain the types of microbes, their morphology and oxygen status*, and their action on proteins and other organic nitrogenous substances**, were investigated.

During the examination of sardines we also established the presence of a saccharolytic group of microbes on the fish surface, and in sprats, the presence in the intestines, of gas formed by the microbes.

The results are recorded in Table II. They indicate that the quantity of microbes in intact sardines was less than in the "split" fish.

In the first and second experiments in which fresh fish were used, proteolytic microbes were found on the surface and in the intestines. The microbes liquefied gelatin and in peptone water formed indole and hydrogen sulfide.

Similar bacteria were found in the muscles of "split" sardines stored for 4 days at 0-2°C and in the muscles of sardines stored for 12 hours at 18–20°C.

In the third experiment putrefactive bacteria were found on the surface, in the muscles, and in the intestines of the sardines. These utilized hydrolysis products of the fish proteins which appeared under the influence of the tissue ferments. These bacteria did not liquefy gelatin, but in peptone water they multiplied and formed hydrogen sulfide and ammonia.

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* by inoculating them into the core of a solid agar medium.

** by inoculating them into the core of a gelatin medium and into peptone water and milk.

Table II

Changes in contamination of fish by microorganisms during storage*

Fish	Number of experiment	Duration of storage in hours	Storage temperature in °C	Quantity of microbic cells					
				Whole fish			Split		
				Per 1 cm² of surface	In 1 kg of muscle	In 1 kg of intestines	Per 1 cm² of surface	In 1 kg of muscle	In 1 kg of intestines
Sardine	1	0	0—1	4260	3	26450	—	—	—
		48	0—1	82061	700	65400	—	—	—
		96	0—1	53956	1000	4698000	102521	49000	968000
		0,5	18—20	4260	3	26450	—	—	—
	2	12	18—20	36814	27500	1088900	—	—	—
		24	18—20	Spoilage of fish by putrefaction					
		0	18—20	4213	5	12205	—	—	—
	3	12	18—20	37493	3000	197000	73716	5100	1138700
		0	—	4693	540	11800	—	—	—
Sprat	4	2,5*	25—30	5818	80	9600	1971	10	16840
		0	0—1	320	125	225	—	—	—
Anchovy	5	48	0—1	1762	50	400	526	50	150
		96	0—1	3588	740	225	24935	175	5875

* Unloading and transport time to the refrigerator has already been mentioned

The "splitting" in sprats was not accompanied by a considerable increase in number of bacteria and was not, therefore, a result of the growth and metabolic activity of the bacteria.

In the experiments with anchovy, "splitting" occurred on the second day of storage at a temperature of 0-2°C and was also not connected with the increase in the number of microbes. But with further storage the number of microbes increased, especially on the surface and in the intestines. During the investigations, microorganisms which liquefied gelatin were not found, though in peptone water the microbes multiplied, but did not form ammonia, hydrogen sulfide, or indole.

Hence, the microbiological observations could not explain the occurrence of "splitting" by the growth or metabolism of the microorganisms found in the fish.

Further storage of intact and "split" fish showed that the "splitting" induced further microbial contamination and subsequently the disintegration of the fish tissue was caused, not only by the tissue ferments, but also by the microbial ferments.

The Biochemical Analyses

Fish samples for biochemical analysis were taken at the same times as those for the microbiological analysis.

The initial samples were taken immediately at the fishing sites (sardines, sprats) or after bringing the fish to the factory (anchovy).

When samples of fish stored in boxes were selected (the laboratory analyses of sardines and anchovy), the specimens of intact fish were combined into one sample, as were the "split" fish taken from a different layer.

The sprat samples, intact and "split", were chosen from the refrigerator while the fish were being prepared for freezing. The chosen fish samples were immediately frozen. The frozen samples for analytical purposes were stored in Dewar bottles at a temperature of minus 12°C. Before freezing, the anchovy were eviscerated and minced in a mincing machine. Sardines and sprats were frozen whole and only before the beginning of the analysis were the fish defrosted, eviscerated, and minced. They were defrosted as quickly as possible in order to avoid changes.

During analysis, the moisture, fat, total nitrogen, water-soluble nitrogen fractions, the nitrogen residue, the nitrogen of free α-amino groups, and the pH were all investigated by the afore-mentioned methods in order to determine the extent of proteolytic changes in the fish tissue /3/.

Results of analyses are given in Table III. The results indicate that the moisture and fat changes which occurred in the fish during the storage process had no regular character. The fat content in "split" fish was a little lower than in intact fish.

No difference was observed in the quantity of total nitrogen in either intact or "split" fish, and considerable pH changes were found in the muscles of fresh fish and those stored at various temperatures.

It was also found (Table III) that the content of the water-soluble nitrogenous substances increased, and with it, the content of water-soluble proteins. These increases were observed to be somewhat greater in the "split" fish. The quantity of nonprotein nitrogen, particularly the nitrogen of free α-amino groups, also increased, the increase being more intensive in the intact fish.

Thus, in analyses of sardines stored at a temperature of 18 to 20°C, in the muscles of intact fish, the content of the α-amino nitrogen was 314.5 mg% (as a ratio of the dry substance) and, in the "split" fish, 363.0 mg%. In the intact sprats the nitrogen of free α-amino groups was (as a ratio of the dry substance) 107.7 mg% and in "split" sprats, 187.7 mg%. In analyses of anchovy after 4 days' storage, 174.7 mg% nitrogen of free α-amino groups was found in the tissue of intact fish and in that of "split" fish, 220 mg%.

Comparison of these data on the "split" fish and the content of the nitrogen of free α-amino groups formed in fish during storage indicated that there was some link between the appearance of "splitting" and the intensity of the proteolytic changes. The accumulation of proteolytic products (nitrogen of water-soluble proteins, nonprotein nitrogen and nitrogen of free α-amino groups), and therefore the whole proteolytic process, was more pronounced in the "split" fish than in the intact fish.

Table III

Types of fish	No of experiment	Conditions under which test samples were taken, and storage conditions	Moisture in %	In % of the dry substance		pH	In % of total nitrogen				
				Fat	Total nitrogen		Watersoluble nitrogen	Nonprotein nitrogen	Protein nitrogen	Nitrogen of watersoluble proteins	Amino-nitrogen
Sardines	1	After catch	78.44	15.07	12.33	7.26	33.45	13.25	86.75	20.42	0.63
		After 12 hours' storage at 15-20°	76.52	16.82	12.30	7.20	30.79	14.50	85.50	16.49	1.02
	2	After catch	78.20	9.03	13.37	7.00	35.22	15.93	84.07	19.27	1.15
		After 12 hours' storage at 15-20°									
		a) whole fish (intact)	77.99	8.99	13.63	7.23	47.39	23.02	76.98	24.32	2.30
		b) "split" fish	77.33	8.16	13.00	7.23	52.23	25.19	74.81	27.06	2.79
	3	Fish frozen immediately after catch	77.29	12.37	13.32	7.11	31.83	14.84	85.16	17.02	0.98
		Fish frozen 1 hour after catch, stored at 15-20°	77.37	12.37	13.07	7.05	30.37	15.14	84.83	15.20	1.01
		After catch	78.44	15.07	12.33	7.26	33.45	13.25	86.75	20.42	0.63
	4	After 48 hours' storage at 0-1° (average sample)	77.47	16.33	12.51	7.24	31.56	13.13	86.88	18.17	0.88
		After 96 hours' storage at 0-1°									
		a) whole fishes (intact)	76.04	17.36	12.18	7.20	30.94	16.25	83.75	14.68	1.16
		b) "split" fish	74.50	18.27	11.64	7.15	29.69	15.89	84.11	13.80	1.14
Sprats	1	After catch	76.56	10.88	13.35	—	—	14.08	85.92	—	1.07
		After delivery into refrigerator									
		a) whole fish (intact)	75.48	16.35	12.56	—	—	17.75	85.25	—	1.10
		b) "split" fish	76.29	14.89	12.72	—	—	16.90	83.10	—	1.42
	2	After catch	73.76	11.55	12.04	6.60	36.21	15.03	84.97	20.25	0.91
		After delivery to refrigerator									
		a) whole fish (intact)	73.25	15.47	12.04	6.60	34.14	14.70	85.30	19.47	0.89
		b) "split" fish	74.09	11.35	12.31	—	38.99	17.24	82.76	21.79	1.52
Anchovy	1	After catch	62.46	53.89	7.59	6.85	33.65	20.81	79.19	12.84	1.28
		After 48 hours of storage at 0-1°									
		a) whole fish (intact)	64.59	45.69	7.96	6.96	—	—	—	—	—
		b) "split" fish	65.07	44.66	8.17	6.99	—	—	—	—	—
		After 96 hours' storage at 0-1°									
		a) whole fish (intact)	64.18	46.51	7.76	6.97	43.16	26.91	73.09	16.25	2.25
		b) "split" fish	66.66	39.53	8.55	7.06	45.61	28.91	71.09	16.70	2.57

CONCLUSIONS

Owing to a dearth of experimental material, an exhaustive explanation of the causes of "splitting" in small fish cannot be given. But the experiments clearly indicate that the biochemical processes in the body of the dead fish play an important role in the occurrence of "splitting", even if they are not the main factor.

Observations made on the development of the microorganisms did not show any clear link between "splitting" and the development and metabolic activity of the microorganisms. But it was clear that the bacterial contamination helped to intensify the proteolytic processes, and therefore accelerated "splitting".

An increase in temperature also accelerated the "splitting" process.

The reason for the different rates at which "splitting" occurred in the various samples of fish of the same kind was not clear, but we may suppose that it was due to the individual differences in the chemical composition of the fish.

The carbohydrate content of the tissues and the intensity of their decomposition have a known influence on the pH, and therefore their influence on the intensity of the hydrolytic action of tissue catepsins was also known.

The quantity of fat in the fish tissue also influenced the rate of "splitting". According to our results there was less in "split" fish than in intact fish. Hence, we may suppose that the tissue of lean fish was more subject to proteolysis than that of fat fish.

The age and physiological state of fish probably also had considerable bearing on the rate of "splitting". Thus, in the experiments with anchovy it was observed that "splitting" occurred more frequently in young fish than in mature specimens.

No connection between the "splitting" and the changes in the moisture, fat, and nitrogenous substances contents of the fish was observed. The "splitting" decreased the commercial value of the fish from the point of view of sanitary requirements because the fish surface thus destroyed enabled different microorganisms to enter the fish tissue. The "splitting" worsened the appearance of the fish. From these facts we may conclude that quick freezing of small fish immediately after catching and keeping them in a frozen state until preparation is essential. The fish should be stored in thin layers. All operations connected with transport of the fish should also be carried out as quickly as possible.

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STORAGE OF FROZEN FISH GLAZED BY THE ADDITION OF ANTIOXIDANTS

(Khranenie morozhenoi ryby glazirovanoi s dobavleniem antiokislitelei)

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The quality of frozen fish during storage deteriorated as a result of moisture loss and oxidation of fish fat, and because the fat acquired a bitter taste. This taste was acquired particularly quickly in fish with very fat meat (Acipenseridae), or in fish whose fats have a high acid number (e.g., herrings).

Glazing was used in order to prevent drying of the frozen fish. The glaze prevented the fish surface from coming into contact with the air, prevented moisture evaporation, and inhibited the fat oxidation process. Studies by VNIKhI /1,2/ verified the fact that glazing prolonged duration of storage of frozen fish (carp, bream, pike,perch) at a temperature of $-18^{\circ}C$ by 4 to 5 months.

A number of papers by local and foreign research workers have dealt with the investigation of methods preventing fat oxidation.. A considerable number of these experiments were made on more or less pure fats taken from muscle or connective tissue (lard, butter, cod-liver oil), and were directed towards the search for a "stabilizer" or antioxidants among different chemical fat-soluble substances. But only a very few experiments have been made on the prevention of fat oxidation within the animal tissue, especially that of fish meat preserved by different methods.

The only possible way to apply the antioxidizer,so as to prevent fat oxidation from occuring in frozen fish, was to include it in a fish glaze. For this reason a water-soluble antioxidizer had to be found. According to the results obtained by foreign research workers, such substances could include citric, ascorbic and glutamic acids /7/, monosodium glutamate /13,15,16/, nordihydroguaiaretic acid /6,8,9,12,14/, and also ethyl, propyl, octyl, and dodecyl esters of gallic acid /3,6,10,14/.

The application of more complex compounds e.g., disubstituted aminoethyl-dioxybenzene, 1-oxy-4-ethoxy-7 methyl-5,8-dihydronaphthalene, and others, which are mentioned in a number of patents /4,5,7/, were also recommended.

The purpose of our work was to find antioxidants for use in the prevention of fat changes in small herrings such as Baltic sprats and anchovy-like Caspian sprats, which are known to acquire a bitter taste quickly in their frozen state. For our purpose we used glutamic acid, monosodium glutamate, and a mixture of ascorbic and citric acids (1:1).

Our experimental method was as follows:-

Fresh fish(Baltic sprats, Caspian sprats)were cleaned in water and frozen into small bricks in iron molds. The freezing temperature for the Baltic sprats was $30^{\circ}C$, and for the Caspian sprats, $-20^{\circ}C$.

The frozen fish brick was glazed with a water solution containing antioxidants in a concentration of 0.1 to 0.2%. For control purposes bricks were glazed with fresh water; unglazed bricks were also made. The glazing was done in freezers at a temperature of -10 to -15°C, and was performed by submerging the brick 3 times into the water or antioxidant solution for periods of 2 to 3 seconds with intervals of 15 minutes between submergings.

With this method the glaze on the bricks reached 2 to 3 mm, and the weight of glaze was from 8.5 to 11% of the weight of the brick (1 to 1.5 kgs). The fish bricks were frozen and glazed at the place of supply—Baltic sprats in the Liepa Refrigerating Factory in May, and Caspian sprats in the refrigerator-ship "Assora" (freezing) and in the Makhachkala Refrigerating Factory (glazing) in September.

The prepared specimens of glazed and unglazed frozen fish bricks were taken to Moscow where they underwent experimental storage in refrigerators. Baltic sprats were preserved at a temperature of -15°C and -25°C, but Caspian sprats only at -15°C.

Before and during storage the fish were subject to organoleptic and chemical examinations every 1 to 2 months and for analytical purposes one fish brick was used in each case. In the organoleptic examination the brick was viewed, defrosted, and boiled, and the taste and smell of the fish and broth were examined.

During the chemical examination most attention was paid to the fat analysis, in which the acid, oxyacid, and iodine numbers were investigated.

Fat for analysis was obtained from minced fish dehydrated with sodium sulfate using ether extraction. The liquid thus obtained was concentrated in order to obtain from 7 – 8% to 12 – 13% of the fat content. In order to determine the acid number, we used 15 ml of the liquid, for the peroxide number, 5 ml, and for the iodine number, 3 ml. Simultaneously the fat content of the liquid was examined. According to our observations the above-mentioned method gave sufficiently precise results, approximating those obtained by indirect fat examination, but this method of examination was considerably simpler.

Results of Investigations of Baltic Sprats

Large sprats 19 to 21 cm long were used for the experiments. The fish were caught at night and frozen the next morning.

Table I records results of the analysis of fresh sprat samples before freezing.

Table I

Material investigated	Content in %		Characteristics of fat obtained	
	Moisture	Fat	Acid number	Oxyacid number
Whole fish.	78.4–84.2	5.3–7.4	20.5	0
Fish meat.	69.8–77.5	3.5–5.1	13.5	0

According to Table I, the fresh Baltic sprats had a high acid number, especially the fat portions extracted from the whole fish. For this reason, in subsequent analyses, we eviscerated the fish during the freezing process and removed the fat from the meat only.

The baltic sprats stored at $-25^{\circ}C$ were examined after 1, 3, 6, 8, $9\frac{1}{2}$ and 11 months of storage. Those stored at $-15^{\circ}C$ were examined after 2, 3, 5, 7, $9\frac{1}{2}$ and 11 months. The results of the chemical analysis of the fat extracted from sprats after different time intervals are recorded in Tables II and III. The examination indicated that storage at $-25^{\circ}C$ was more satisfactory than storage at $-15^{\circ}C$. Hence the control batch of fish glazed with water without antioxidants did not change after 3 months' storage at $-25^{\circ}C$, while the quality of similarly prepared fish stored for the same time at $-15^{\circ}C$ deteriorated. In these latter samples the meat became hard and a slight nuance of bitterness was detected in tasting. Similar results were noted upon organoleptic comparison of glazed fish to which antioxidants had been added and which were stored at different temperatures.

The changes in chemical characteristics did not always coincide with the results of the organoleptic investigations of the fish. In particular we did not observe any clear link between the increase in the acid number of the fat and the presence of a bitter nuance in the taste. The peroxide and iodine numbers were much more significant, and they coincided with data of the organoleptic examinations. However, the peroxide number of the fats undergoing oxidation did not increase constantly, since they were being further converted into aldehydes, ketones, and acids. Hence it was possible to find fish with a bitter taste and a low peroxide number.

After 5 months' of storage at a temperature of $-15^{\circ}C$ Baltic sprats glazed with glutamic acid and monosodium glutumate had completely retained their commercial qualities. When Baltic sprats were glazed with a mixture of ascorbic and citric acids, they had only a slight nuance of bitterness, while those glazed with pure water were markedly bitter.

Examination after 7 months of storage at the same temperature, of fish glazed with glutamic acid or with a mixture of ascorbic and citric acids and pure water, showed that the acid number of fat had considerably increased, while the iodine number had decreased. Correspondingly the taste of the fish also deteriorated. Fish glazed with water without antioxidants were unsaleable. Better results were obtained with preserved Baltic sprats glazed with monosodium glutamate. The quality of all specimens of Baltic sprats stored at $-25^{\circ}C$ for 6 months remained practically unchanged. After $9\frac{1}{2}$ months of storage Baltic sprats glazed with monosodium glutamate also remained unchanged, but those glazed with other antioxidants (glutamic, ascorbic and citric acids) had considerably deteriorated in quality. In spite of this they could still be included in the top quality grade. At the same time, the control specimens glazed with pure water had changed to such a degree that they were far below standard.

Results of Experiments with Anchovy-like Caspian Sprats

The Caspian sprats examined were caught by means of a fish suction-pump with the aid of a bright lux lamp. The sprats were 9 to 11.5 cm long, and were frozen on board ship immediately after being caught. The analysis of the fish brought to Moscow, gave the following results in % before experimental storage (beheaded, eviscerated fish were the subject of the analysis).

1.	Moisture	77.5
2.	Fat	2.4
3.	Acid number of fat	31.6
4.	Peroxide number of fat	1.91
5.	Iodine number of fat	156.9

Thus, in the initial period of sprat storage, the fat contained a considerable quantity of free acids and peroxides.

Table II

No of batch	Antioxidant	Concentration in %	CHARACTERISTICS OF SPRAT FAT STORED AT — 15 C																	
			2 months			3.5 months			5 months			7 months			9.5 months			11 months		
			Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number
1	Glutomic acid	0.1	34.9	0.05	129.0	37.2	0.08	121.8	47.14	0.09	129.0	46.3	0.03	118.8	51.0	0,11	131.0	—	—	—
2	Glutomic acid	0.2	36,5	0.08	—	33.2	0.05	113.7	42.3	0.10	118.7	51.0	0.06	114.9	56.8	0,16	144.3	—	—	—
3	Monosodium glutamate	0.1	32.6	0.05	130.2	31.5	0.08	—	44.2	0.11	131.4	47.7	0,06	115.0	46.0	0,16	123.2	—	—	—
4	Monosodium glutamate	0.2	28.1	0,05	131,1	42.8	0,12	133.2	46,8	0.19	114.4	51.2	0.07	116.4	47.74	0,17	110,8	52.1	0.24	120.0
5	Ascorbic + citric acid	0.1	32.6	0.05	134.4	—	0.08	—	43.1	0.15	109.1	—	0.07	82.2	49.5	0.12	115,2	—	—	—
6	Same	0.2	34.6	0.05	134.1	31.9	0.08	137.5	46.1	0.17	114.9	—	—	—	57.0	0,07	141.1	49.2	0.41	114.6
7	Glazing with water without oxidant (control test)	—	28.0	0.12	129.6	33.2	0.06	124.2	47.6	0.09	101.4	50.4	0.12	96.5	45.2	0.43	127.2	—	—	—

Table III

No of batch	Antioxidant	Concentration in %	CHARACTERISTICS OF SPRAT FAT STORED AT — 25°C														
			1 month			6 months			7 months			9.5 months			11 months		
			Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number
1	Glutonic acid	0.1	23.3	0	126.2	20.4	0.13	107.8	25.0	0.05	116.5	27.0	0.14	99.2	—	—	—
2	Same	0.2	29.1	0	125.5	34.1	0.13	128.7	21.8	0.07	105.2	34.4	0.15	121.5	—	—	—
3	Sodium glutamate	0.1	22.2	0	139.8	25.3	0.09	119.9	23.8	0.07	105.9	25.4	0.17	104.4	22.2	0.29	119.2
4	Same	0.2	18.3	0	134.8	22.4	0.07	103.9	21.6	0.08	97.1	22.0	0.23	121.6	23.8	0.22	112.9
5	Ascorbic citric acid	0.1	19.6	0	122.8	29.3	0.08	120.3	24.4	0.10	126.4	20.3	0.21	110.7	25.1	0.17	110.0
6	Same	0.2	23.7	0	135.3	20.8	0.05	107.4	27.1	0	101.6	33.6	0.21	123.7	22.1	0.24	118.3
7	Glazing with water without oxidant (control test)	—	25.0	0	133.7	25.9	0.14	113.8	22.2	0.05	98.2	31.0	0.36	117.9	18.5	1.00	106.5

Table IV

No of batch	Antioxidant	Concentration in %	CHARACTERISTICS OF SPRAT FAT STORED AT — 15°C														
			2 months			3 months			4 months			6 months			7 months		
			Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number	Acid number	Oxyacid number	Iodine number
1	Glutamic acid	0.1	30.5	4.82	151.6	37.4	1.56	151.6	38.0	1.45	153.9	45.9	5.21	154.7	—	—	—
2	Same	0.2	33.6	5.61	156.2	40.9	2.05	142.7	37.8	3.19	135.6	44.1	3.80	153.0	37.9	3.47	124.9
3	Monosodium glutamate .	0.1	30.6	3.50	147.0	41.3	orc.	134.7	43.9	1.73	159.7	38.6	5.79	133.4	—	—	—
4	. . . . .	0.2	37.4	4.95	160.3	36.9	1.84	141.3	35.0	2.53	146.5	37.0	5.33	155.8	40.2	3.16	148.3
5	Acorbic citric acid · Same	0.1	32.0	4.20	156.1	41.8	2.78	168.3	38.6	1.39	157.8	37.0	3.64	131.7	—	—	—
6	. . . . .	0.2	32.6	4.57	158.2	39.9	1.64	143.3	33.0	5.09	134.3	38.8	4.58	145.6	43.1	4.24	104.6
7	Glazing with water only, without any antioxidant.	—	26.1	4.35	151.6	35.2	1.84	118.5	36.9	7.85	138.6	Storage ceased			—	—	—
8	Unglazed fish	—	30.2	11.51	158.0	31.5	3.46	135.3	35.9	10.67	130.7	Storage ceased			—	—	—

Results of fat investigations carried out on sprats during storage at a temperature of $-15^{\circ}C$ are recorded in Table 4.

The investigations indicated that, even after 2 months of storage, unglazed Caspian sprats, sprats glazed with water without antioxidants, developed a slightly bitter taste. The acid number of the fat in the fish specimens did not change, but the peroxide number increased considerably, especially in the unglazed fish. Over the same period, Caspian sprats glazed with glutamic acid or with a mixture of ascorbic and citric acids did not change to any great extent, and those glazed with glutamic acid, remained completely unchanged.

After 3 months of storage unglazed and water-glazed Caspian sprats lost their market value completely. Within the same period, the fish glazed with antioxidants had not changed greatly. Caspian sprats glazed with monosodium glutamate were in the best condition. As in the experiments with Baltic sprats the chemical characteristics of the fat did not quite coincide with the results of the organoleptic examination. Thus the acid numbers of fat of Caspian sprats glazed with 0.1% and 0.2% solutions of monosodium glutamate increased considerably by the end of the third month of storage, but the taste of the fish remained good. A comparison of peroxide numbers of Caspian sprat stored for 2 and for 3 months indicated that in the third month of storage the fat oxidation process increased, but the primary oxidation products changed to secondary products, aldehydes, fatty acids and others.

Fish tasting, performed after 4 and 6 months' storage, indicated that Caspian sprats glazed with monosodium glutamate (0.2%), remained in a good condition.

Investigations thus performed did not allow us to reach any definite conclusions concerning the stability of Caspian sprats glazed with antioxidants, because only small batches of fish were stored for experimental purposes, and these were stored only at $-15^{\circ}C$. But the results obtained indicated sufficiently clearly that glazes prepared with the addition of monosodium glutamate or from a mixture of ascorbic and citric acids prevented oxidation in Caspian sprats much more satisfactorily than glaze made from pure water.

CONCLUSIONS

1. Glazing of frozen Baltic and Caspian sprats with a 0.2% solution of monosodium glutamate, a mixture of ascorbic and citric acids, or with glutamic acid, increased their frozen storage life considerably.

2. The most effective of all the antioxidants investigated was monosodium glutamate; the least effective was glutamic acid. The mixture of ascorbic and glutamic acids had a medium effect.

3. Baltic sprats glazed with pure water were preserved without changes in quality at a temperature of $-15^{\circ}C$ for 3 months. Under the same storage conditions Baltic sprats glazed with glutamic acid solution and those glazed with a mixture of ascorbic and citric acids remained in a good condition for 6 to 7 months. The same fish stored under the same conditions but glazed with monosodium glutamate retained the taste and smell of fresh fish for 9 months.

4. The quality of Caspian sprats that were glazed with pure water and stored at $-15^{\circ}C$, remained unchanged for only 2 months, those glazed with 0.1% monosodium glutamate or a mixture of ascorbic and citric acids, for 4 months, and those glazed with 0.2% of these antioxidants for 6 months.

5. By lowering the temperature from -15°C to -25°C the storage life of the frozen sprats was increased approximately twofold.

Investigations of other antioxidants and their value in storage duration of frozen Caspian sprats and other fish of the herring group will be continued.

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CHANGES IN SALTED FISH DURING STORAGE IN SALT SOLUTIONS

(Izmeneniya v solenoi rybe pri khranenii v solevykh rastvorakh)

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During preservation of fish in salt, fish weight decreases because of moisture loss.

Loss in fish weight during salting depends on the species, age and freshness of fish, the presence or absence of scales, the method of evisceration used before salting, as well as the method and conditions of salting.

During storage and also during salting various changes in quality and weight can be observed in the fish.

It is well known,that salted fish can be preserved with dry salt or in salt solutions. The latter method is used for preserving fat fish, especially herrings and semi-prepared "balyks" made from sturgeon and salmon. Salt solutions prevent the fish from coming into contact with air, and prevent spoilage and drying during storage and transportation. However, during storage some changes occur.

During storage of medium and highly salted fish in salt solutions, we find a predominance of weight changes. In slightly salted fish, besides considerable weight changes. Changes also occur in chemical composition and especially in salt content. The increase in the salinity of the fish often causes misunderstanding between the seller and consumer when defining their quality.

Thus, in order to ensure fewer changes in quality, optimum conditions had to be found for keeping different kinds of fish in salt solutions.

For this reason,we investigated weight, protein, and fat changes in salted Caspian herring and semi-prepared "balyks" made from sturgeon during storage in salt solutions of different concentrations. In order to avoid processes of osmotic and diffusive character, and thus prevent changes in the fish, special attention was paid to the achievement of equilibrium between the salt concentration in the fish liquid sap and the salt solution during storage.

Isotonic, hypertonic and hypotonic salt solutions were used for covering the salted fish.

We considered an isotonic solution to be one in which the salt concentration was equal to the salt concentration of the fish liquid.

Hypertonic and hypotonic solutions were considered to be those in which the salt concentration was respectively more and less than the concentration in the fish liquid.

It was experimentally established that the salt concentration in the fish liquid calculated as the % content of water and salt, was the same as the concentration found in the liquid extracted from the fish meat.

In order to control nitrogen changes in the fish substances during storage of the fish and in salt solutions, the amount of general and nonprotein nitrogen as well as that of the amino acids, were determined periodically, using the usual methods. Acid, peroxide, iodine and fat saponification numbers were investigated in order to control the extent of the changes in fat. These indexes were determined on the ether extract of dehydrated fish-meat, hash treated with Na_2HPO_4.

Experiments on the Storage of Salted Caspian Herrings

The salted herrings were prepared at the Volga-Caspian State Fishing Trust im. "Astrakhan Proletariat". Before salting, the fish were chilled, and the salting was performed in a wooden vat. A small quantity of brine was poured into the vat after which the herrings were introduced, arranged and sprinkled with dry salt. The herrings were then covered with a clean bast mat, upon which was placed a mount of salt in order to press the salted fish. During salting the salt and moisture contents of the fish meat were examined. After 9 days of salting, the salt content of the meat had reached 13.8%, and the moisture content 56.4%. This meant that the herring had reached the medium-salted state. At this stage a portion of the herrings were transferred to barrels and covered with a salt solution, the salt concentration in which was equal to that in the fish-meat liquid.

Of the herrings which remained in the vat, the moisture content after 14 days of salting, was 55.2% and the salt content 16.8%, which meant that the herrings had reached the highly-salted state. These herrings were also transferred to barrels and covered with a salt solution with a salt concentration equal to that of the fish-meat liquid.

The medium and highly salted herrings, packed in barrels, were sent to Moscow for investigation of their storage and other qualities. For storage purposes each batch was divided into four parts which were placed in separate vessels, three of which were covered with freshly prepared solutions of salt of different concentrations, and the fourth, with the brine in which the fish were transported.

The solutions covering the herrings had a percentage salt content as follows:

	For medium-salted herring	For highly salted herring
Hypotonic	17.0	21.7
Isotonic	19.5	23.7
Hypertonic	20.5	24.7
Natural brine	19.2	22.9

The salt contents of the isotonic solutions and of the natural brine were very similar. The fish covered by the natural brine were used as a control.

The herrings covered with the different solutions were stored at a temperature of 5 to 10° C. During their storage the herrings were weighed after 30, 90, and 140 days, an organoleptic examination of quality was made, and samples for chemical analysis were taken.

During the examination the length and weight ratios of different parts of the fish body were examined. The moisture and salt contents in the whole fish and in separate parts of fish body (meat, skin, head, intestines, fins and bones) were also examined. Nitrogen and fat changes were checked in the fish meat only.

On measuring 164 specimens, the average size of the body (from the tip of the head to the end of scales) was 25.9 cm, the industrial length (from the middle of the eye to the end of the anal fin) was 20.1 cm, the width of the body was 7.0 cm, and the thickness, 2.6 cm. The weight of the salted herring in the separate batches varied from 225 to 305 g and was on the average 250 g.

In every case the weight of the herrings during storage in the salt solutions changed only insignificantly. Thus, according to Table 1, the herring weight decreased only from 0.2 to 2.0%, and, in a few cases, a weight increase from 0.4 to 0.7% was observed. The slight weight variations observed in the herring were probably connected with individual differences in the separate fish specimens but the difference in the salt solution concentration in which the fish were stored apparently did not affect fish weight at all.

Table I

Herring	Decrease (-) or increase (+) of the herring weight in % of its total during storage		
	After 30 days	After 90 days	After 140 days
Medium-salted			
During storage in salt solutions:			
hypotonic	-0.9	-0.4	—
isotonic	+0.4	-0.3	-0.7
hypertonic	-1.1	+0.7	-1.7
Highly Salted			
During storage in salt solutions:			
hypotonic	-2.0	-0.2	-0.3
isotonic	-0.7	-0.5	-0.7
hypertonic	-0.3	+0.5	-1.2

No changes were observed in the weight ratio of the different parts of the fish during storage in the different salt solutions either in medium or in highly salted herring.

The average weight of the different parts of the fish body, in percent of the whole body weight, were: meat - 54.6, head - 14.9, bones - 6.7, skin - 5.3, fins - 1.8, and intestines - 16.1%.

Table II records results of an analysis performed on medium-salted herrings (the whole fish and separate parts of the fish body) and on the brine in which they were stored. The results of the analysis of highly salted herrings are given in Table III.

Hence, according to data in Tables II and III, the moisture and salt contents

of the herring in different parts of its body during the entire storage period remained practically constant.

Taking the weight of the separate parts of the fish body, and the results of analysis, we can establish the moisture and salt distribution in the body of the salted fish. Corresponding calculations show (in Table IV) that the meat of the medium-salted herring contained from 56 to 59% of the whole moisture content, and from 50 to 58% of the whole salt content of the fish body. In the meat of highly salted fish the moisture content was from 53 to 57%, and salt content was from 51 to 58% of the total content of the fish (Table V). Hence the character of the moisture and salt distributions were very similar.

Table II

Storage conditions of medium-salted herring	Material investigated	Content in %					
		Moisture			Salt		
		30 days	90 days	140 days	30 days	90 days	140 days
In natural brine (control test)	Whole fish	55,72	58,78	59,25	13.92	14.64	15.64
	Meat	58.44	59.81	59.62	14.50	15.20	15.64
	Head	54.49	56.41	56.42	13.75	14.35	15.06
	Bones	50.78	60.69	51.47	12.83	12.63	13.90
	Skin	51.88	50.88	47.69	12.83	12.63	13.32
	Fins	48.62	46.62	46.30	11.46	12.05	13.61
	Intestines	60.60	62.46	61.90	16.04	16.07	16.79
	Brine	—	—	—	18.70	18.94	19.11
In hypotonic salt solution	Whole fish	57.16	56.76	60.76	12.59	14.06	14.77
	Meat	59.69	61.32	60.78	13.10	14.35	14.48
	Brine	—	—	—	16.96	18.36	18.82
In isotonic salt solution	Whole fish	58.27	58.05	59.36	12.04	12.62	14.19
	Meat	59.30	60.51	61.66	11.47	14.00	14.48
	Head	55.87	55.48	59.85	12.62	12.62	13.32
	Bones	47.84	50.41	51.47	11.87	10.61	13.32
	Skin	52.94	50.24	52.22	11.30	11.48	12.16
	Fins	48.92	46.84	47.61	11.58	12.62	11.87
	Intestines	62.31	61.49	63.83	16.34	18.52	15.64
	Brine	—	—	—	19.49	19.52	18.82
In hypertonic salt solution	Whole fish	57.92	59.01	59.06	14.00	13.77	14.77
	Meat	60.59	60.75	61.90	14.31	13.77	16.21
	Brine	—	—	—	18.61	19.52	19.40

The salt solutions in which the herrings were stored gradually became saturated with the substances exuded from the fish body (Table VI). The amount of solid substances in the solutions after 30 days of storage was 3 to 5%, and after 140 days, reached 5 to 9%.

These changes were directly connected with changes in protein substances in the herring meat.

Thus, according to the data in Table VII, the general nitrogen content of the salted fish meat decreased during storage, while its content in the salt solutions increased. After 140 days of storage, the total nitrogen in the meat of medium-salted herring decreased by 0.68 to 0.84%, and in highly salted herring, by 0.41 to 0.55%

Table III

Storage conditions of highly salted herring	Material investigated	Content in %					
		Moisture			Salt		
		30 days	90 days	140 days	30 days	90 days	140 days
In natural brine (control test)	Whole fish	57.75	58.82	58.80	16.03	16.07	17.37
	Meat	57.21	59.34	59.01	16.61	15.78	16.79
	Head	54.15	56.63	56.91	14.89	16.07	16.51
	Bones	49.21	52.65	51.26	13.16	14.92	14.48
	Skin	49.07	51.52	47.17	13.74	13.77	14.48
	Fins	44.10	47.69	47.34	12.59	13.77	14.19
	Intestines	61.76	63.10	63.23	18.38	18.36	18.53
	Brine	—	—	—	20.62	21.23	20.56
In hypertonic salt solution	Whole fish	54.85	56.07	56.57	15.75	17.22	16.79
	Meat	56.80	58.34	58.93	12.31	16.93	16.51
		—	—	—	21.77	21.81	22.00
In isotonic salt solution	Whole fish	55.00	53.89	56.19	15.77	15.49	17.95
	Meat	56.85	56.28	56.56	15.77	17.22	17.95
	Head	53.27	52.83	53.72	16.63	16.07	16.79
	Bones	48.45	50.12	50.23	15.48	14.64	14.48
	Skin	50.02	49.63	49.99	14.74	14.35	15.64
	Fins	45.23	45.67	45.82	15.62	13.77	14.48
	Intestines	59.22	59.58	58.33	16.92	18.36	19.11
	Brine	—	—	—	22.37	22.38	23.74
In hypotonic salt solution	Whole fish	54.95	54.04	56.43	12.31	16.07	16.21
	Meat	57.01	55.35	56.80	12.59	16.93	17.66
	Brine	—	—	—	22.77	22.67	23.74

Table IV

Storage conditions of medium-salted herring	Material investigated	In % of total content in whole fish					
		Moisture			Salt		
		30 days	90 days	140 days	30 days	90 days	140 days
In natural brine (control test)	Meat	55.9	57.8	58.0	55.1	57.8	57.2
	Head	14.5	12.6	15.3	14.5	12.6	15.3
	Bones	5.7	5.7	5.2	5.7	5.6	5.3
	Skin	5.0	4.3	4.7	4.9	4.2	4.9
	Fins	1.2	1.3	1.3	1.2	1.3	1.4
	Intestines	17.7	18.2	15.5	18.6	18.4	15.8
In isotonic salt solution	Meat	55.6	59.2	56.4	49.8	56.3	56.3
	Head	14.9	13.2	15.0	15.8	12.3	14.2
	Bones	5.9	5.3	5.8	6.9	4.5	6.3
	Skin	5.4	4.9	5.5	5.4	4.6	5.3
	Fins	1.5	1.3	1.4	1.7	1.4	1.5
	Intestines	16.6	16.0	15.9	20.4	20.8	16.4

Table V

Storage conditions of strongly salted herring	Material investigated	In % of total content in whole fish					
		Moisture			Salt		
		30 days	90 days	140 days	30 days	90 days	140 days
In natural brine (control test)	Meat	57.0	52.6	56.4	57.6	50.8	55.7
	Head	13.6	15.6	13.7	13.0	16.1	13.8
	Bones	6.2	5.9	5.8	5.7	6.0	5.7
	Skin	4.6	4.2	4.1	4.4	4.1	4.4
	Fins	1.3	1.6	1.5	1.3	1.6	1.6
	Intestines	17.3	20.1	18.5	17.8	21.3	18.8
In isotonic salt solution	Meat	54.0	55.5	55.6	52.0	55.7	55.8
	Head	14.5	15.2	14.8	15.8	15.2	14.6
	Bones	6.5	5.9	6.2	7.3	5.7	5.7
	Skin	4.9	3.8	5.3	4.8	3.6	5.3
	Fins	1.6	1.6	1.9	1.9	1.6	1.9
	Intestines	18.3	18.0	16.1	18.2	18.2	16.7

Table VI

Herring	Kind of salt solution in which herring was kept	Content of compact substances remaining in salt solutions in %		
		After 30 days	After 90 days	After 140 days
Medium-salted	Natural brine	4.54	7.67	7.88
	Hypotonic solution	5.16	6.39	9.46
	Isotonic "	3.77	4.86	6.78
	Hypertonic "	2.84	6.67	7.09
Highly salted	Natural brine	3.43	5.24	7.03
	Hypotonic solution	3.38	4.98	5.67
	Isotonic "	3.11	5.50	4.60
	Hypertonic "	2.95	5.05	5.05

The smaller nitrogen loss in highly salted herrings can be explained by the more intensive protein coagulation in the meat of highly salted herrings. This fact inhibited the transfer of nitrogenous substances from the fish body to the brine. Despite the fact that the salt concentration of the brine differed only slightly, the nitrogen loss from the meat of medium-salted fish during storage in isotonic salt solutions was a little less than during storage in hypotonic solutions. In highly salted herrings the decrease in total nitrogen was approximately the same in every case.

At the beginning of storage (up to 30 days), the increase in quantity of total nitrogen in the salt solutions (hypotonic, isotonic, and hypertonic) was considerably more intensive than in natural brine. Upon further storage, a large quantity of nitrogen accumulated in the solutions which had a lower salt concentration.

Table VIII records results of observations concerning the nonprotein nitrogen and nitrogen of amino acids contents in fish meat. We shall evaluate the data of the ratio of nonprotein nitrogen to the total nitrogen content of the fish meat. In the initial period of storage (up to 30 days), in both medium and highly salted

herrings stored in different salt solutions and in natural brine, the ratio showed almost no change, but with further storage it gradually increased.

Table VII

Storage conditions of herring	Total nitrogen content in %							
	Before storage		After storage					
			30 days		90 days		140 days	
	Fish meat	Salt solution	Fish meat	Salt solution	Fish meat	Salt solution	Fish meat	Salt solution
	Experiments with medium-salted herring							
In natural brine	3.43	0.63	3.22	0,90	3.01	1.07	2.69	1.21
In hypotonic solution	3.43	0	3.38	0.72	2,73	1.11	2.62	1.25
In isotonic solution	3.43	0	3.05	0.55	3.07	0.94	2,83	1.08
In hypertonic solution	3.43	0	3.31	0.55	2.93	0.99	2.75	1.11
	Experiments with highly salted herring							
In natural brine	3.32	0,50	3.31	0.65	3.23	0.83	2.77	0.90
In hypotonic solution	3.32	0	Uncertain	0.50	3.26	0.76	2.86	0.87
In isotonic solution	3.32	0	The same	0.50	3.18	0.76	2.85	0.77
In hypertonic solution	3.32	0	3.21	0.54	3.23	0.72	2.91	0.82

In the medium-salted herrings the ratio of nonprotein nitrogen to total nitrogen, after 140 days of storage, increased from 15.1 to 22.3-25.2%, and in highly salted herrings, from 11.6 to 14.6-24.1%. Thus, in the meat of medium-salted herrings we found a larger content of nonprotein nitrogen than in the meat of highly salted herrings.

Simultaneously with the increase of nonprotein nitrogen in the herring meat, that in the salt solution also increased. But the largest amount was found in those solutions in which the medium-salted herrings were stored.

The amount of amino acid nitrogen in the herring meat and in the salt solutions considerably increased during storage. Hence, in the meat of medium-salted herring,the quantity of amino acid nitrogen (in ratio to the total nitrogen) increased from 2.5 to 8.6-14.1% after 140 days of storage, and in the meat of highly salted herrings, from 2.8 to 7.16-12.2%.

The data obtained indicated that the hydrolysis process of the proteins was more intensive in fluid having a smaller salt content.

Fat removed from the herring meat,before and after salting,had the chemical characteristics recorded in Table IX.

Thus,in the fat of herrings taken for salting we found some signs of the beginning of hydrolysis (the presence of free acids in fish) and oxidation (the presence of peroxides). During salting,a considerable increase of acid, peroxide,and fat numbers took place. But on organoleptic evaluation of the salted herrings no signs of fat changes were observed.

Table VIII

Storage conditions of herring	Content of nonprotein nitrogen in mg per 100 g (in % of the total mitrogen)								Content of amino acid nitrogen in mg per 100 g (in % of total mitrogen)							
	Before storage		After storage						Before storage		After storage					
			30 days		90 days		140 days				30 days		90 days		140 days	
	In meat	In salt solution	Fish meat	Salt solution	Fish meat	Salt solution	Fish meat	Salt solution	Fish meat	Salt solution	Fish meat	Salt solution	Fish meat	Salt solution	Fish meat	Salt solution
Experiments with medium-salted herring																
In natural brine	521 (15.1)	406 (64.4)	500 (15.5)	483 (53.6)	625 (20.8)	739 (69.0)	656 (24.4)	776 (64.1)	87 (2.5)	133 (21.1)	178 (5.5)	132 (14.6)	166 (5.5)	335 (14.6)	285 (10.6)	407 (33.6)
In hypotonic solution	521 (15.1)	0	531 (15.7)	365 (50.63)	625 (22.9)	729 (65.6)	661 (25.2)	791 (63.3)	87 (2.5)	0	180 (5,31)	162 (22.5)	264 (9.7)	358 (32.4)	372 (14.1)	472 (37.8)
In isotonic solution	521 (15.1)	0	448 (14.7)	427 (77.6)	625 (20.3)	624 (66.4)	646 (22.8)	760 (70.3)	87 (2.5)	0	172 (5,3)	153 (28.0)	245 (8.0)	319 (33.9)	238 (8.6)	398 (36.8)
In hypertonic solution	521 (15.1)	0	427 (14,0)	396 (71.9)	562 (19.1)	614 (62.0)	614 (22.3)	719 (64.7)	87 (2.5)	0	218 (7,8)	159 (29.0)	238 (8.1)	312 (31.5)	268 (9.7)	376 (33.8)
Experiments with highly salted herring																
In natural brine	385 (11.6)	302 (50.4)	406 (12.2)	364 (56.1)	448 (13.8)	500 (60.2)	666 (24.1)	552 (61.3)	92 (2.8)	60 (12.0)	148 (5.6)	156 (24.0)	202 (6.3)	270 (32.5)	327 (12.2)	274 (30.4)
In hypotonic solution	385 (11.6)	0	385 (10,0)	354 (70.8)	427 (13.0)	489 (64.4)	489 (17.1)	573 (65.8)	92 (2.8)	0	144 (4.3)	131 (26.3)	184 (5.6)	247 (32.5)	249 (8.7)	294 (33.8)
In isotonic solution	385 (11.6)	0	375 (10,7)	344 (68.7)	416 (12.8)	500 (65.7)	437 (15.3)	550 (71.4)	92 (2.8)	0	126 (3.3)	125 (25.1)	168 (5.3)	241 (31.8)	242 (8.4)	263 (34.1)
In hypertonic solution	385 (11.6)	0	396 (12,3)	323 (58.7)	416 (12.8)	490 (68.0)	427 (14.6)	531 (64.7)	92 (2.8)	0	104 (3.0)	126 (23.3)	200 (6.2)	249 (34.6)	222 (7.6)	252 (30.7)

In Tables IX and X are shown the fish fat changes observed during salting and storage. After 30 days of storage the acid numbers of the fat in medium-salted herrings were higher than in highly salted ones; but with further storage, after 90 days, the acid numbers were higher in the highly salted herrings; finally, after 140 days, the changes were almost the same in both kinds of herrings. By the end of storage the acid numbers of the fat had increased, on the average, to approximately 3 times of their initial value at the beginning of storage.

Table IX

Herring	Fat indexes			
	Acid number	Peroxide number % at (iodine)	Saponification number	Iodine number
Initial (fresh) Herring after salting:	5.7	0.08	172.2	149.0
after 5 days	8.2	0.25	–	–
" 9 "	15.1	0.52	–	–
" 14 "	16.2	0.49	175.1	148.3

The results obtained lead us to conclude that different salt concentrations in the solution surrounding the fish, and in the fish meat, do not have any effect on the character of changes in the acid number of the fish fat.

At the beginning of the experimental storage, the peroxide number of the fat of salted fish was from 0.18 to 0.19.

During the first 30 days of storage, the peroxide number of the fat increased considerably and reached its highest value. On further storage the peroxide number of the fat decreased. No regularity in the decrease was noted. This was probably caused by the fact that the formation of the peroxides and their conversion to aldehydes and acids did not take place at the same rate.

In our experiments the iodine number decreased during the salting of the herrings, but during the experimental storage the iodine number gradually increased until at the end of the storage period (after 140 days), it had almost reached the value present in the fresh fish before salting. Similar variations of the iodine number in salted herrings and in other fish were also noted by other investigators.

The fat saponification number increased during salting (see Table IX). During storage in salt solutions a tendency for the saponification number to increase was also noted (Table X). The observed increase of the saponification number indicated the formation of acids of lower molecular weight in the fat as the result of fat oxidation. During the storage of the herring, an initial increase followed by a decrease, and then a renewed increase in the saponification number was observed in some cases. These variations in the saponification number of the fat can be explained by the fact that the water-soluble acids of low molecular weight so formed, pass from the fish into the salt solution.

On comparing the acid number with the saponification number of fat, we can see some connection between these characteristics. The lower values of the acid number correspond to the lower values of the saponification number. This indicates that, in some way, the formation of free acids in fat is caused not only by hydrolysis but also by fat oxidation.

Table X

Experiments Concerning Storage of Salted Semi-manufactured "balyks"

Storage condition of herring	Acid number of fat				Peroxide number of fat (in % of iodine)				Iodine number of fat				Saponification number of fat		
	On canning before storage	After storage			On canning before storage	After storage			On canning before storage	After storage			On canning before storage	After storage	
		30 days	90 days	140 days		30 days	90 days	140 days		30 days	90 days	140 days		30 days	90 days	140 days
Experiments with medium-salted herring																
In natural brine	14.9	18.8	29.0	31.1	0.18	1.60	0.83	1.06	117.3	125.4	135.1	138.0	191.3	191.5	170.8	185.7
In hypotonic solution	14.9	21.6	30.5	39.9	0.18	1.34	0.56	0.83	117.3	126.1	132.4	139.5	191.3	187.5	221.7	201.4
In isotonic solution	14.9	20.1	32.9	37.7	0.18	1.50	1.00	0.87	117.3	125.0	130.1	139.9	191.3	192.3	189.8	215.6
In hypertonic solution	14.9	24.6	29.4	38.1	0.18	1.28	0.88	1.05	117.3	125.1	128.7	134.0	191.3	197.1	235.2	198.0
Experiments with highly salted herring																
In natural brine	13.7	12.0	40.4	37.6	0.19	1.16	0.85	0.75	123.5	135.3	135.9	137.7	214.0	181.7	223.4	226.2
In hypotonic solution	13.7	17.7	36.9	42.4	0.19	1.34	1.25	0.74	123.5	134.1	137.6	139.9	214.0	198.4	208.6	238.6
In isotonic solution	13.7	15.4	38.8	38.5	0.19	1.39	1.39	0.68	123.5	133.2	136.5	137.5	214.0	187.7	239.1	223.0
In hypertonic solution	13.7	16.4	39.5	39.4	0.19	1.36	0.88	0.79	123.5	131.7	138.50	141.3	214.0	195.1	197.8	217.3

The experiments were performed in the Caviar-Balyk Plant of the Astrakhan Fishing Combine im. Mikayan.

The salted "balyks" were prepared in the following manner:

First experiment: Salted flanks of white sturgeon with a moisture content of 60.0% and a salt content of 7.3% were placed in wooden barrels and covered by a salt solution of a specific weight of 1.10, isotonic to the fish liquid.

Each barrel contained 135 kg of fish and 25 to 30 liters of salt solution. Because the fish had a low salinity, to each barrel containing salt solution was added one of the following preservatives (in g per barrel):

1) Sodium benzoate	135 g (0.1% of fish weight)
2) Peroxide	50 g
3) Citric acid	100 g
4) Mixture of borax and boric acid 1:1	400 g

In addition, before being placed in the barrels, the salted fish were immersed for one day in a salt solution, the specific weight of which was 1.16. This solution contained the liquid used for preserving in the proportion of 1% to the fish weight.

As a control, in one barrel the fish were covered with a salt solution which had a specific weight of 1.16, as is accepted in production.

A total of 10 barrels were prepared with fish flanks; of these, two were covered with a pure salt solution of 1.10 specific weight, six with salt solution of 1.10 specific weight to which preservatives had been added, and two control barrels were covered with salt solutions of 1.16 specific weight.

half of the barrels thus prepared were subjected to uninterrupted storage at a temperature of 0 - minus 2°. The rest were stored for one month at 0 - minus 2°, after which they were placed in a room at a temperature of minus 8 - minus 10°C.

Second experiment: Fish flanks salted in the usual way, having a salt content (for each piece) of 4.0 to 6.8%, were packed for storage in the following manner:

Two parts of the fish of 135 kg each were placed in the usual barrels and covered with 25-30

liters of salt solutions having specific weights of 1.16 and 1.10.

Three other parts of the fish, each of 60 kg, were placed in small barrels and covered with a salt solution of 1.16 specific weight to which were added anti-oxidants or preservatives: in one barrel 600 g of the preserving liquid was added, in the second, 25 g of peroxide, and in the third, 60 g of citric acid.

After immersion for one day in the solution containing preservatives the fish were placed in wooden boxes lined with wax paper. Each box contained 30 kg of fish flanks(14 to 15 pieces). Two boxes were prepared from each kind of fish, specimens being taken for analysis from fish packed both in barrels and in boxes. The results of the analysis are recorded in Table XI.

Table XI

Characteristics of samples	Content in %	
	Moisture	Salt
Fish treated with curing liquids		
box No 1, sample No 1	68.0	4.0
Same, sample No 2	61.5	4.5
Same, box No 2, sample No 1	61.0	5.6
Same, sample No 2	66.5	10.2
Fish treated with peroxide,		
box No 1, sample No 1	66.5	6.8
Same, sample No 2	61.5	5.6
Same, box No 2, sample No 1	61.0	4.0
Same, sample No 2	63.5	7.3
Fish treated with citric acid		
box No 1, sample No 1	66.5	5.1
Same, sample No 2	59.0	10.2
Same, box No 2, sample No 1	53.5	7.9
Same, sample No 2	63.5	5.6
Fish in barrel covered with salt		
solution, specific weight 1.16	61.5	4.5
Same, specific weight 1.10	59.0	4.5

The fish packed in barrels and in boxes were kept for the first 17 to 20 days at a temperature of 0° to minus 2°C, and then at minus 8 to minus 10°C.

Third experiment: Fresh fish flanks were chilled with an ice-salt mixture and put into chests. During packing, each layer of fish was sprinkled with salt; after one day the chests were filled with saturated salt solution. The absorption of salt by the fish took approximately 8 days. The temperature of the salt solution in the chest during salting was from 1 to 3°C. At the end of salting the salt content of various pieces fluctuated from 4.5 to 7.6%; the average moisture content was 63%. The salted fish were kept on shelves for 2 days in order to formize their salinity. Results of the analysis of the salt contents (in %) of the fish after uniformization were as follows:

Sample No 1	7.9
" No 2	7.9
" No 3	6.2
" No 4	10.2
" No 5	8.8

The moisture content of the fish after uniformization (average sample from

five fish) was 62.0%. The average salt concentration in the fish liquid was 11.3% which corresponded to a salt solution with a specific weight of 1.08.

When uniformization was reached, the fish under investigation were placed in ten barrels, five of which were filled with isotonic salt solutions with a specific weight of 1.08, and the other five (control) barrels with salt solution with a specific weight of 1.16, as is accepted in production. Each barrel contained 140 kg of fish which were covered with 25 to 30 kg of salt solution. Preservatives were added to three of the barrels containing fish and a salt solution with a specific weight of 1.08. To one barrel a mixture of borax and boric acid 2:3 weighing 500 g was added, to the second 25 g peroxide, and to the third 140 g sodium benzoate.

Before the fish were dispatched from Astrakhan to Moscow and during transportation, they were stored at a temperature of 0 to minus 2°C, and after arrival in Moscow, in the Moscow Fishing Combine Refrigerator, at a temperature of minus 3 to 4°C.

During storage and preparation the experimental samples of salted flanks of white sturgeon were periodically examined for determination of their quality as indicated by organoleptic signs. During this examination we reweighed samples from each package (barrel and box). These samples had been previously tagged with their initial weight. Simultaneously with the reweighing, samples of the brine were taken for chemical analysis. Because part of the brine was lost by opening the barrels,the brine in each barrel was supplemented by a salt solution of the same concentration after inspection.

During observations of the fish from the two initial experiments which were stored at a temperature of 0° to minus 2°C and minus 8 to minus 10°C , it was found that in barrels where the fish were covered with a hypertonic salt solution (specific weight 1.16), the specific weight of the solution decreased to 1.12-1.13 during the first 20 days of storage, after which there was almost no change. In the barrels where the fish were covered with an isotonic salt solution (specific weight 1.10) the specific weight of the solutions remained without change,or increased only slightly,after two months of storage.

The salt content of the fish, packed in boxes and barrels and covered with salt solutions, increased in every case. The application of preservatives and antioxidants did not give any positive result. It was found that the preserving liquid caused the fish to become more compact, the fish body to become discolored, and a "curing" smell to be clearly felt. Peroxide, on the other hand, made the fish surface lighter but did not prevent it turning yellow. The consistency of the fish did not change. Citric acid and benzoic acid caused the fish to become soft, and did not prevent it from turning yellow. The phenomenon of the fish turning yellow could not be prevented by the addition of boracic preparations.

After 17 days of storage in boxes at a temperature of 0 to minus 2°C, and after one month of storage at minus 8 to minus 10°C, fish treated with antioxidants and preservatives showed no signs of deterioration in quality,caused by superficial yellowing.

Table XII indicates weight changes in the control samples of the fish flanks observed during salting and storage of the fish in the third experiment.

Pertinent results of observations concerning moisture and salt changes in the fish, as well as changes in salt solution concentrations and their solid substances content, are recorded in Tables XII and XIV.

Table XII

No of sample (barrel)	Storage conditions of salted fish flanks	Weight of salted fish flanks in % of weight of fresh flanks (before salting)				
		After 8 days of salting	After keeping to attain equilibration	After salting		
				19 days	61 days	117 days
1	Covered with hypertonic salt solution (specific weight 1.16)	87.5	86.5	87.9	86.9	89.7
2	Same	87.8	87.3	89.7	91.3	94.2
3	"	87.5	86.1	89.2	92.0	95.4
4	"	86.2	85.6	89.4	92.1	95.5
5	"	89.0	88.4	90.7	93.6	98.4
	Average.....	87.6	86.9	89.4	91.1	94.6
6	Covered with isotonic salt solution (specific weight 1.08)	88.1	87.3	91.8	93.7	98.0
7	Same	87.3	87.3	91.5	95.3	98.3
8	The same with addition of borac acid and borax	87.9	87.3	92.2	94.6	98.3
9	The same with addition of peroxide	86.0	85.0	89.3	91.0	96.0
10	The same with addition of sodium benzoate	87.0	86.	93.1	98.4	103.9
	Average.....	87.3	86.6	91.6	94.6	98.9

Thus, according to Table XII, the weight of salted fish flanks covered by both hypertonic and isotonic salt solutions, increased with storage. The average increases in the weight of fish flanks during storage, as a % ratio of their initial weight at the moment of packing in barrels were as follows:

Duration of storage	Covered with a hypertonic solution	Covered with an isotonic solution
After 19 days	2.9	5.7
" 61 days	4.9	9.2
" 117 days	9.0	14.2

Thus, upon covering with an isotonic salt solution, the weight of fish flanks during storage increased a little more than upon covering with hypertonic solutions.

During the first 19 days of storage the specific weight of the brine in barrels where the fish were covered by a hypertonic solution with a specific weight of 1.16 decreased to 1.11-1.12, after which it did not change. In the barrels containing fish covered by an isotonic solution, the specific weight of the brine had increased from 1.08 to 1.10 after 19 days, and by the end of storage (after 117 days) it had reached 1.105 to 1.11. Simultaneously with the changes in specific weight a considerable increase in the solids content of the solution was observed in each case, resulting from the extraction of the solids from the fish body. The quantity of solids (without salt) in solution was 2.57 – 3.84% after 19 days of storage, and, after 117 days, 3.49 – 4.26%.

The relative moisture content of the fish covered with a hypertonic solution decreased slightly during storage (an average of 62.0 to 60.9%) and in fish covered by isotonic solution, increased a little (an average of 62.0 up to 66.5%). The salinity of the fish increased in every case, and after 19 days was 7.9-9.8%, after 61 days from 9.2-10.8%, and after 117 days, from 9.5 to 11.1%.

Table XIII

Number of sample (barrel)	Storage conditions of fish plants (3rd experiment)	Changes in chemical composition (in %) of salted fish flanks during storage											
		After 19 days				After 61 days				After 117 days			
		Moisture	Salt	Fat	Salt concentration in fish liquid	Moisture	Salt	Fat	Salt concentration in fish liquid	Moisture	Salt	Fat	Salt concentration in fish liquid
1	Covering with hypertonic salt solution (specific weight 1.16)	—	—	—	—	63.54	10.49	—	14.10	63.85	11.09	—	14.79
2	Same	61.59	9.85	10.87	13.80	62.89	10.81	10.15	14.76	60.75	10.71	13.22	14.98
3	"	—	—	—	—	59.63	10.20	—	14.60	58.14	10.80	—	15.66
6	Covering with isotonic salt solution (specific weight 1.08)	63.07	7.95	10.81	11.19	64.48	9.85	10.15	13.25	64.85	10.14	9.81	13.52
8	The same with addition of boracic acid and borax	64.39	9.54	9.12	12.90	64.07	9.54	11.11	12.96	67.95	10.11	7.02	12.98
9	The same with addition of peroxide	63.77	8.58	10.73	11.85	65.20	9.22	9.08	12.38	63.91	9.55	10.89	13.00
10	The same with addition of sodium benzoate	64.04	9.22	9.71	12.58	65.34	9.54	9.39	12.74	67.80	10.42	8.02	13.31

Table XIV

No of Sample (barrel)	Storage conditions of fish flanks (3rd experiment)	Change in salt solution during storage of fish flanks								
		After 19 days			After 61 days			After 117 days		
		specific weight	salt in %	solid substances in %	specific weight	salt in %	solid substances in %	specific weight	salt in %	solid substances in %
2	Covering with hypertonic salt solution (specific weight 1.16)	1.120	14.94	2.68	1.115	14.62	3.68	1.110	15.34	3.86
3	Same	1.120	14.62	2.57	1.115	14.30	3.48	1.115	14.48	4.11
4	Same	1.120	14.62	3.01	1.120	14.30	3.85	1.120	15.06	3.59
5	Same	1.110	13.35	3.47	1.110	13.67	4.46	1.110	13.61	3.89
6	Covering with isotonic salt solution (specific weight 1.08)	1.100	12.72	3.38	1.105	12.71	3.97	1.110	13.32	3.83
7	Same	1.100	12.08	3.43	1.100	12.71	3.51	1.105	13.03	4.26
8	The same with addition of boracic acid and borax	1.100	12.72	3.84	1.105	12.71	3.60	1.105	13.03	3.93
9	The same with addition of peroxide	1.100	12.72	2.50	1.100	12.71	3.62	1.110	13.61	3.65
10	The same with addition of sodium benzoate	1.100	12.08	3.75	1.105	12.71	3.53	1.110	13.32	3.49

These moisture and salinity changes in the fish also caused the salt concentration of the fish liquid to change (see Table XIII). In the initial salted fish before covering with salt solutions, the salt concentration in the fish liquid was on the average 11.3%: at the end of storage (after 117 days), the salt concentration in the liquid of the fish covered with a hypertonic solution, reached an average of 15.1% (an increase of 3.8%), and in fish covered by an isotonic solution it was on the average 13.2% (an increase of 1.9%).

The afore-mentioned changes in fish salinity and in salt concentration in their liquid are connected with the swelling of the fish during storage, and, in the case of fish covered with an isotonic solution, are greater than when a hypertonic solution is used.

The results of our observations of changes in the quantity of total nonprotein and amino acid nitrogen in fish preserved in salt solutions are given in Tables XV and XVI.

On examining these Tables, it can be seen that during storage the quantity of the total nitrogen in the fish decreased slightly whereas in the salt solutions it increased. The decrease in the quantity of the total nitrogen in the fish was most marked during the initial period of storage.

The hydrolysis of proteins proceeded at approximately the same rate during the storage of fish in both isotonic and hypertonic solutions. Simultaneously with the increase of the nonprotein nitrogen content in the fish an increase in its content in the salt solution also took place. At the end of storage (after 117 days) the quantity of nonprotein nitrogen in the fish was from 13.7 to 15.9% and of amino acid nitrogen - from 4.0 to 5.5% of the total nitrogen.

Changes in fish fat indexes during storage were characterized by the results recorded in Table XVII.

Table XV

No of sample barrel	Storage conditions of fish flanks (3rd experiment)	Total nitrogen content (in %) during storage					
		19 days		61 days		117 days	
		Meat	Salt Solution	Meat	Salt Solution	Meat	Salt Solution
2	In hypertonic salt solution (specific weight 1. 16)	2. 88	0. 41	2. 53	0. 53	2. 51	0. 56
3	Same	—	0. 36	—	0. 42	—	0. 58
4	"	—	0. 36	—	0. 43	—	0. 53
5	"	—	0. 37	—	0. 47	—	0. 54
6	In isotonic salt solution (specific weight 1. 08)	2. 91	0. 43	2. 46	0. 53	2. 45	0. 60
7	Same	—	0. 43	—	0. 48	—	0. 60
8	The same with addition of boracic acid and borax	2. 76	0. 37	2. 24	0. 48	2. 20	0. 59
9	The same with addition of peroxide	2. 91	0. 38	2. 52	0. 44	2. 50	0. 56
10	The same with addition of sodium benzoate	2. 76	0. 43	2. 11	0. 43	2. 11	0. 54

Table XVI

No of Sample (barrel)	Storage conditions of fish flancs (3rd experiment)	Content of non protein nitrogen in mg per 100 gr (in % of total nitrogen) during storage						Content of amino acid nitrogen in mg per 100 gr (in % of total nitrogen) during storage					
		19 days		61 days		117 days		19 days		61 days		117 days	
		Fish	Salt Solution	Fish	Salt Solution	Fish	Fish Solution	Fish	Salt Solution	Fish	Salt Solution	Fish	Salt Solution
2	In hypertonic salt solution (specific weight 1.16).	334 (11.3)	251 (61.1)	345 (13.6)	261 (49.2)	346 (13.7)	317 (56.6)	114 (4.0)	69 (16.9)	122 (4.8)	95 (18.0)	133 (15.3)	111 (19.8)
3	Same	—	219 (60.8)	—	240 (57.2)	—	317 (55.5)	—	60 (16.6)	—	87 (20.6)	—	89 (15.4)
4	Same.	—	240 (66.7)	—	271 (63.1)	—	307 (58.0)	—	58 (16.2)	—	88 (20.4)	—	102 (19.2)
5	Same	—	210 (64.9)	—	240 (51.1)	—	317 (58.7)	—	50 (13.5)	—	87 (18.4)	—	100 (18.5)
6	In isotonic salt solution (specific weight 1.08).	386 (13.2)	261 (60.7)	386 (15.7)	282 (53.2)	385 (15.6)	365 (60.9)	96 (3.3)	75 (17.5)	122 (4.6)	84 (15.8)	122 (4.9)	120 (20.0)
7	Same	—	272 (63.1)	—	282 (58.7)	—	298 (49.6)	—	66 (15.3)	—	94 (19.6)	—	132 (22.0)
8	The same, with addition of boracic acid and borax.	323 (11.7)	240 (64.9)	334 (14.9)	261 (54.4)	336 (15.5)	346 (58.6)	97 (3.5)	75 (20.2)	111 (4.9)	93 (19.4)	122 (5.5)	112 (19.0)
9	The same, with addition of peroxide	345 (11.8)	240 (63.2)	345 (13.6)	261 (59.3)	346 (13.7)	336 (60.0)	88 (3.1)	55 (14.5)	104 (4.2)	89 (20.2)	101 (4.0)	107 (19.6)
10	The same, with addition of sodium benzoate	323 (11.7)	251 (58.3)	334 (15.8)	261 (60.7)	336 (15.9)	298 (55.2)	101 (3.7)	64 (16.7)	108 (5.1)	83 (19.4)	110 (5.2)	98 (19.1)

The indexes of changes in the fish fat were as follows:

Fat indexes	Before salting	After salting
Acid number	0.7	3.2
Peroxide number	0	0.5
Iodine number	109.3	106.7
Saponification number	180.7	181.0

Thus, during salting and storage of fish the acid and peroxide numbers of fat increased considerably. It should be noted that at the end of the experiment, the acid number of the fat of fish stored in hypertonic solutions was lower than that in fish stored in isotonic solutions. Especially high was the acid number of fish covered with an isotonic solution containing peroxide, which probably stimulated the fat decomposition.

Table XVII

Storage conditions of fish flanks (3rd experiment)	Acid number			Peroxide number			Iodine number			Saponification number		
	Duration of storage of fish flanks in days											
	19	61	117	19	61	117	19	61	117	19	61	117
In hypertonic salt solution (specific weight 1, 16)	7.0	9.1	9.2	0.68	1.14	1.24	138.1	126.1	114.3	170.8	196.7	194.7
In isotonic salt solution (specific weight 1.08)	4.5	9.0	11.8	0.43	1.04	1.21	128.7	124.1	119.7	157.9	177.6	179.7
Same	6.3	6.5	11.6	0.56	1.02	1.96	127.1	121.9	118.3	162.1	182.9	180.0
The same, with addition of peroxide	11.7	13.5	19.7	0.55	1.13	1.62	122.0	121.1	118.3	162.1	182.9	180.0
The same, with addition of sodium benzoate	7.1	10.8	11.6	0.45	1.02	2.07	118.2	116.5	121.7	164.1	176.1	198.6

The iodine number of fat in samples of salted fish flanks examined during storage in salt solutions were higher than in samples before salting, and they fluctuated either by increase or by decrease of the iodine numbers. The fluctuations of the iodine numbers thus observed were probably caused by the formation of a considerable number of the intermediate products of fat oxidation, chiefly aldehydes.

The fat saponification numbers decreased in every case at first, but increased toward the end of storage.

The decrease in the saponification number of fish fat during storage was probably caused by the formation of water soluble low-molecular-weight acids which partially passed from the fish into the salt solution.

CONCLUSIONS

1. During storage in salt solutions of a concentration approximating that of the salt concentration of the fish liquid medium and highly salted Caspian herrings changed only slightly in weight. The changes in herring weight was from minus 2 to 0.7% after a storage period of 140 days.

2. During storage of salted white sturgeon flanks in iso- and hypertonic salt solutions they increased in weight and swelling took place. Very considerable swelling was observed in fish flanks stored in isotonic salt solutions, in which the increase in weight after 117 days of storage reached 14.2%.

Simultaneously with this weight increase, an increase in the salt content was also observed. During storage in isotonic salt solutions, the salinity of the fish flanks increased on an average by 2% (from 8 to 10%).

3. The storage of salted herring and white sturgeon flanks in salt solution was accompanied by fish protein hydrolysis together with a partial loss of nitrogenous substances which were extracted by the solutions. Hydrolysis and oxidation of fish fat also took place.

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EXPERIMENTAL STORAGE OF FISH DRIED BY THE FREEZE DRYING METHOD

(Opytnoe khranenie ryby vysushenui metodum sublimdtsii)

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Russian and foreign investigations indicate that the best method for drying various food substances and biological preparations is drying them under vacuum from the frozen state, i.e., by the freeze-drying method (1/2/3/4/5/6/7/8/9/10/).

Dried by this method, food products (meat, fish, vegetables, and fruits) swell better in water and, after soaking, recover their initial properties more satisfactorily than those dried under natural conditions, in air or in a drying apparatus at an increased temperature.

An evaluation of the properties of fish meat dried by different methods, using the point system proposed by N. A. Voskresenkii /2/, showed that: the fish dried by the freeze-drying method rated 23 points, cod dried by the cool air method (in natural conditions) rated 19, and the same kind of fish dried by the hot air method (in a drying apparatus) rated 12 points.

The freeze-drying method has several advantages over the cool-air method. In the former, dehydration of the products proceeded at a quicker rate and could also be regulated; it was not dependent on the season or on the weather.

The freeze-drying method is now widely used in the preparation of drugs, especially penicillin. This technique is not used however with food products, including fish, because commercial methods of packing and storage of the dried products have not been sufficiently developed.

During storage of the freeze-dried meat of cod at room temperature in open vessels, or wrapped in white paper, we observed that after a certain time interval a yellowing of the fish took place, and deep yellow or brown spots appeared on the surfaces of the fish. The paper in which the fish was wrapped also became yellow, which indicates that the colored products formed in the fish were of a volatile nature. We believed that the phenomenon of yellowing was connected with the decomposition and oxidation of its fat under the influence of oxygen present in the air. So we tried treating the yellowed fish and the paper in which they were wrapped, with different organic solvents — alcohol, ether, chloroform and acetone, but the color of the fish and paper did not change. After filtering and evaporating the solvent with which the fish and paper were treated no trace remained on the filter paper. It was thus established that the colored products formed in the dried fish were insoluble in the usual solvents.

During similar storage of freeze-dried meat of other fish (pike perch, pike sheatfish), yellowing was also observed, but it appeared after a longer time interval than in the cod.

It was also observed that pieces of dry cod meat stored in the dark were of a deeper yellow than those stored in the light. Very interesting results concerning these phenomena were obtained from the two following experiments.

In the first experiment, a conical flask was filled with freeze-dried cod meat and sealed with a stopper covered with paraffin. Then the flask was placed on a window sill facing south. The part of the meat which was exposed to the sunlight did not turn yellow but the yellow color was pronounced in the part of the fish meat which was not exposed to sunlight.

In the second experiment, pieces of dried cod meat were placed in a wide vessel covered with a piece of paper and left near the window. After two to three months the fish pieces were only tinged with yellow, while the under side of the paper with which the vessel was covered, had become uniformly stained a deep yellow color, the size of the stain being equal to the diameter of the vessel.

These observations indicate that light causes evaporation of the colored products from the fish, and is not the cause of their formation within the fish.

An attempt to use cellophane and oilpaper, as well as boxes made of paraffin-treated cardboard as wrapping for dried cod meat, did not give any positive results in the prevention of the fish from turning yellow.

Together with the phenomenon of yellowing a gradual change in taste was noted in the dried cod stored without packing. After wetting and boiling, the stored dry cod, unlike the freshly dried cod, had a more firmer texture and a correspondingly worse taste.

Changes in the texture and taste of the stored cod depended on the humidity of the air; the changes were greater when the humidity increased.

In order to find a better method for storing the freeze-dried fish, we studied the effect of oxygen and air humidity on the quality of the dried fish. The experimental methods were as follows:

The frozen cod and pike perch were cut into slices 15 mm thick, and immediately dried under the laboratory vacuum-drying apparatus. The residual pressure in the apparatus was 0.5 to 1 mm Hg, and the temperature was within the range of 40°C (at the beginning of drying) to 60°C (at the end of drying). The temperature of the fish during the drying process was controlled by a thermocouple inserted into the fish slices. To control the weight changes in the fish and ascertain the end of the drying process, separate fish slices were laid on a special balance placed within the drying apparatus near the viewing window.

Drying lasted for 20 hours, and the dried fish pieces were stored under the following conditions:

1) Packed in the usual plywood box lined with wax paper.

2) Packed in plastic bags and placed in the plywood box.

3) Packing was done in an atmosphere of dry air in a desiccator over heated calcium chloride.

4) Under vacuum (from 10 to 20 mm Hg) in an evacuated desiccator over heated calcium chloride.

5) In an atmosphere of carbon dioxide in special hermetically sealed glass vessels.

In order to obtain moisture-free gas, the vessels containing the fish were filled with carbon dioxide taken from the usual containers, and passed through two wash bottles with strong sulfuric acid.

Samples were taken every month from the fish stored by each method, as well as from the initial frozen and dried fish.

As the basic nutritious substances in the fish meat are proteins whose state depends on the structure and hydrophilic character of muscle tissue as well as on the texture and taste of the fish when used as food, special attention was paid in the chemical analysis to the characteristics of the nitrogenous substances. So we determined the content of the total protein and nonprotein nitrogen, nitrogen of water-soluble and salt-soluble proteins, and amino-acid nitrogen.

We also determined the moisture content of the fish, and the swelling ability of dry fish. The latter we calculated by finding the increase in fish weight after soaking for 30 minutes.

The different forms of nitrogen were determined using the accepted methods /6/.

Table I shows the results of the chemical analysis of cod and pike perch meat before and after drying.

Table I

Changes in chemical composition of fish during drying

Material investigated	Content in fish in %			In % of total nitrogen					
	Moisture	Total nitrogen (N)	Protein (Nx6.25)	Protein nitrogen	Nitrogen of water-soluble proteins	Nitrogen of salt-soluble proteins	Nitrogen of insoluble proteins	Nonprotein nitrogen	Amino acid nitrogen
Cod									
frozen	81.07	2.90	18.13	88.6	14.9	8.1	65.5	11.4	1.4
dried	4.31	14.41	90.06	85.7	8.3	7.4	70.0	14.3	3.2
Pike perch									
frozen	81.10	2.70	16.88	90.3	16.2	30.4	43.7	9.7	3.0
dried	2.76	14.70	91.88	89.2	14.1	18.3	56.8	10.8	1.8

From Table I we see that the drying was accompanied by protein changes in the fish meat. The quantity of soluble proteins after drying was considerably less, especially in the experiments with pike perch where the initial content of soluble proteins was higher than in cod.

Thus the degree of denaturation of proteins upon drying was in some way connected with the protein changes which took place during the freezing and cold storage of the fish before drying. Hence, when the proteins in the frozen fish had

markedly changed (experiments with cod), the change during drying were less extensive.

The dried fish (pike perch and cod) looked good. The fish pieces preserved in the initial form were light, having a fine porous structure. After soaking, the dried fish resembled defrosted fish.

Finger pressure applied to the pieces of soaked pike persh did not cause any noticeable water extraction, while with the pieces of cod a considerable quantity of water was extracted. A similar state could be observed in frozen cod after defrosting.

Weight increases in dried cod were 286.4%, and in dried pike perch, 228% (correspondingly the weight of the soaked fish was 386.4% and 328.0% of the dry fish weight). Hence,the dried fish weight after soaking reached only from 76 to 77% of the initial weight of the frozen fish before drying. Accordingly, moisture absorbed by the fish during soaking was only 71 to 72% of the initial content of the fish before drying.

Thus, the moisture absorption ability of the fish meat decreased as a result of drying and protein denaturation.

The texture, taste,and smell of the boiled (after soaking) specimens of dried fish did not differ greatly from those of the boiled specimens of frozen fish, but were a little less glutinous and juicy.

Results of observation on moisture changes, swelling ability, and the contents of different forms of nitrogen in dried fish during storage under different conditions are recorded in Tables II, III and IV.

According to Table II, we see that at the end of the first month of storage,the moisture content of fish stored in boxes lined with wax paper considerably increased, and reached 11 to 12%. This corresponded to the uniformized moisture of fish dried in air of the usual relative room humidity (from 60 to 70%). Packing of dried fish in polyethylene bags also did not prevent the fish from absorbing moisture, but absorption took place more slowly than in the fish stored in boxes lined with wax paper. The highest degree of moistening was observed upon storage in carbon dioxide, and was probably caused by the fact that the carbon dioxide used was not completely anhydrous.

During storage in normal air, and in vaccum using calcium chloride, the fish "moisture" content fluctuated within the margin of error. The presence of moisture in fish samples stored with calcium chloride over a sufficient period is hardly probable, and we may assume that in this case the loss of fish weight during drying in the drying cabinet at 100°C was the result of the removal from the fish of some volatile substances, but not of water itself.

There was practically no change in the swelling ability (Table II) of samples of dried cod in water, stored for 4 months in an atmosphere of dried air with calcium chloride under vacuum and with carbonic acid. But in samples stored in boxes lined with wax paper, there was a considerable decrease, and vice versa. Those samples stored in polyethylene bags showed a small increase. This slight increase in swelling ability was observed in dried pike perch packed in polyethylene bags after 3 to 4 months of storage. Under other storage conditions the swelling ability of dried pike perch gradually decreased.

The ratio of the total quantity of protein to nonprotein nitrogen in fish (Tables III and IV) remained almost constant under all storage conditions. But at the same time

we observed some changes in the ratio of nitorgen of soluble and nonsoluble proteins. According to Table III, in cod and pike perch packed in boxes lined with wax paper, the quantity of water and salt-soluble proteins considerably decreased after one month of storage, while the quantity of insoluble proteins increased.

Table II

Changes in moisture and in swelling ability of dried cod and pike perch during storage

Storage Conditions	Moisture content in fish in %					Swelling ability (weight of moistened fish in % of dry fish)				
	Initial	Storage duration (in months)				Initial	Storage duration (in months)			
		1	3	3	4		1	2	3	4
Experiment with Cod										
In plywood boxes lined with wax paper	4.31	11.93	—	12.04	12.50	386.0	327	—	356	333
In plastic bags	4.31	—	7,05	8.02	10.91	386.0	381	401	431	420
In an atmosphere of dry air (over $CaCl_2$)	4.31	2.57	3.06	3.87	4.35	386.0	382	363	393	326
Under vacuum (over $Ca\ Cl_2$)	4.31	3.47	4.04	4.14	5.29	386.0	381	386	391	383
In carbon dioxide	4.31	6.92	6.06	6.79	8.84	386.0	378	374	367	369
Experiment with Pike Perch										
In plywood boxes lined with wax paper	2.76	11.47	10.85	12.32	—	328	316	279	291	272
In plastic bags	2.76	7.34	9.18	10.69	—	328	318	287	367	351
In an atmosphere of dry air (over $Ca\ Cl_2$)	2.76	4.12	4.66	3.77	4.52	328	320	284	285	281
Under vacuum (over $Ca\ Cl_2$)	2.76	4.79	4.65	4.53	4.19	328	322	285	261	257
In carbon dioxide	2.76	4.02	5.46	6.59	5.10	328	295	224	231	234

With other storage methods some decrease in the quantity of insoluble proteins was observed in cod in the fourth month of storage, and in pike perch, after 2 months of storage.

It should be noted that it was mainly the salt-soluble proteins that were denatured, and the quantity of water soluble proteins decreased chiefly in fish stored in the plywood boxes lined with wax paper.

The quantity of amino acid nitrogen in the fish differed in various experiments. In most instances, there was a characteristic gradual decrease in the quantity of amino acid nitrogen in cod during storage. This was unlike the pike perch, where an increase was observed. The cause of these changes and their features are unknown and should be investigated in detail in the future.

Organoleptic evaluation of fish samples in the dry and in the soaked state, as well as after boiling (after soaking) in salt water, indicate the following:

After one month of storage, a slight yellowing appeared on the surface of the dried cod stored in the plywood box. After two months the yellow color became more pronounced and increased in depth. After 3 months of storage, distinct brown spots were also observed on the fish surface simultaneously with the deepening of the yellow coloration.

Considerable changes also took place in the texture of the dried fish and instead of its former brittleness, it became more compact and hard. After one month of storage, the taste of the boiled fish also underwent considerable change - the "dryness" of the meat increased and its texture also became more compact. After 3 months the appearance, taste and texture became so poor that it was impossible to use it as food.

It should be noted that after 3 months of storage, despite the increased yellowing, the cod had neither the smell nor the taste of oxidized fat.

Organoleptic changes similar to those occuring in cod were also observed in pike perch packed in boxes. But at the end of the third month of storage a bitter flavor was noted, so storage was stopped.

The fish packed in polyethylene bags, especially cod, kept better than when stored in boxes. Thus, after one month of storage a light yellowish coloring appeared on the fish surface, but the stored boiled fish did not differ in taste or in texture from the fresh boiled fish. After 2 months, the yellow coloring became more pronounced and the taste and texture deteriorated somewhat. In general however, the quality of the fish was satisfactory. At the end of the third month of storage, cod did not lose its saleability, but pike perch had an unpleasant appearance, with brown spots, and a bitter flavor was noted in the taste. We may assume therefore, in comparison with cod, the quicker spoilage of pike perch was caused by abdominal fish fat being smeared on the meat during evisceration and before drying.

Storage of the fish in carbon dioxide and in dry air using calcium chloride gave better results but did not prevent them from turning yellow.

In these cases a slight, superficial yellowing of the fish appeared at the end of the second month of storage, but the smell, taste and texture did not change. Some changes in taste and texture were noted only after the third or fourth month of storage, but the quality of the fish was accepted as good. In vacuum storage a light yellowish color appeared only during the fourth month. Changes were found in the texture of the fish at the end of storage (fourth month). With vaccum storage, the fish lost a considerable amount of its flavor, and took on a neutral taste.

Table III

Changes in the content of protein forms or nitrogen in dried cod and pike perch during storage (in % of total nitrogen)

Storage conditions	Protein nitrogen					Nitrogen of water soluble proteins					Nitrogen of salt-soluble proteins					Nitrogen of insoluble proteins				
	Initial	Storage duration (in months)				Initial	Storage duration (in months)				Initial	Storage duration (in months)				Initial	Storage duration (in months)			
		1	2	3	4		1	2	3	4		1	2	3	4		1	2	3	4
Experiment with Cod																				
In plywood box lined with wax paper	85.7	85.8	—	86.6	85.4	8.3	3.5	—	2.5	2.4	7.4	4.1	—	3.0	—	70.0	78.3	—	81.1	—
In plastic bags	85.7	86.7	85.1	85.1	84.8	8.3	8.4	10.4	7.7	3.2	7.4	—	—	7.2	4,2	70.0	—	—	70,2	77,4
In an atmosphere of dry air (over $CaCl_2$)	85.7	85.4	86.5	85.6	86,2	8.3	7.8	9.4	7.1	8.4	7.4	8.7	8,9	8.7	5.8	70.0	68,9	68.2	69.8	72.0
Under vacuum (over $CaCl_2$)	85.7	86,0	86,7	85,8	86.2	8.3	9.2	10.3	7.5	7.6	7.4	6.8	7,5	8,5	7.2	70.0	70.0	68,9	69.8	71,4
In carbon dioxide	85.7	85,5	85.3	85.1	85.6	8.3	7.8	7.3	7.0	5.0	7.4	7.7	10,5	6.9	4.3	70.0	70.0	67,5	71,2	76,3
Experiment with Pike Perch																				
In plywood box lined with wax paper	89.2	88,9	89.3	89.7	—	14.1	13.5	—	10.3	—	18.3	14.1	—	15.7	—	56.8	61.3	—	63.7	—
In plastic bags	89.2	88,1	89.3	88.9	—	14.1	15.4	13,6	13.8	—	18.3	15.3	11,7	12.8	—	56.8	57.4	64,0	62.3	—
In an atmosphere of dry air (over $CaCl_2$)	89.2	89.0	89.5	89,2	89.5	14.1	12.8	14.7	14.1	13.9	18.3	19.9	15,1	11,0	11.9	56.8	56.3	59,7	61,1	63,7
Under vacuum (over $CaCl_2$)	89.2	88.7	89.1	89.9	89.2	14.1	15.8	15.8	14.9	14.8	18.3	18.5	14,2	13.6	16,4	56.8	54,4	59,1	61,4	58.0
In carbon dioxide	89.2	91.6	88.8	91,6	89.7	14.1	16.2	14,9	16.9	13,3	18.3	18.6	15,0	16.1	15,4	56.8	56.8	58.9	58.6	61,0

Table IV

Changes in the contents of nonprotein forms of nitrogen in dried cod and pike perch (in % or total nitrogen)

Storage conditions	Nonprotein nitrogen					Nitrogen of amino acid				
	Initial	Storage duration (months)				Initial	Storage duration (months)			
		1	2	3	4		1	2	3	4
Experiment with Cod										
In plywood box lined with wax paper	14.3	14.1	—	13.4	14.6	3.2	1.2	—	—	0.8
In plastic bags	14.3	13.3	14.9	14.9	15.2	3.2	1.1	1.2	1.0	1.8
In an atmosphere of dry air (over $CaCl_2$)	14.3	14.6	13.5	14.4	13.8	3.2	1.8	1.5	—	1.2
Under vacuum (over $CaCl_2$)	14.3	14.0	13.3	14.2	13.8	3.2	1.4	1.5	2.2	2.7
In carbon dioxide	14.3	14.5	14.7	14.9	14.4	3.2	1.9	1.4	—	1.4
Experiment with Pike Perch										
In plywood box lined with wax paper	10.8	11.1	10.7	10.3	—	1.8	1.5	2.4	2.6	—
In plastic bags	10.8	11.9	10.7	11.1	—	1.8	2.1	2.3	2.5	—
In an atmosphere of dry air (over $CaCl_2$)	10.8	11.0	10.5	10.8	10.5	1.8	2.0	—	2.6	3.3
Under vacuum (over $CaCl_2$)	10.8	11.3	10.9	10.1	10.8	1.8	2.7	2.1	3.1	2.3
In carbon dioxide	10.8	9.4	11.2	9.4	10.3	1.8	1.9	2.8	—	3.1

The results of our observations concerning changes in taste and texture are similar to the results of the chemical investigations. In cases where moistening of the fish occurred during storage, it was accompanied by protein changes and a deterioration in taste and texture.

The phenomenon of yellowing is probably connected in some way with the fish becoming moist. Oxygen was not observed to have any effect on the development of yellowing in fish. The yellowing appeared in the fish at practically the same time, no matter which of the different storage methods was used.

CONCLUSIONS

1. During the freeze-drying of fish a partial denaturation of proteins, especially of the salt-soluble fraction, took place.

2. The basic changes which took place in the dried fish during storage were yellowing and protein "aging", which was manifested by the decrease of its hygroscopicity. The protein changes caused a deterioration in the organoleptic qualities of the fish. The texture of the boiled fish became compact and hard, the viscidity of the meat decreased, and it became less juicy.

The rate of change in the dried fish during storage was dependent upon storage conditions.

3. Moistening of fish during storage, caused the yellowing process and the protein changes to take place faster. Hence, in order to prevent the frozen-dried fish becoming moist during storage, it was necessary to pack them by special methods. Oxygen was not found to have any effect on the yellowing of dried fish.

4. Frozen-dried fish can be stored for three to four months in air free from moisture, and in carbon dioxide without considerable change. Dried fish can be stored for two months in polythylene bags under room conditions.

The fish stored in plywood boxes lined with wax paper should be kept in a dry storehouse for not more than one month.

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THE EFFECT OF STORAGE TEMPERATURE ON THE DEVELOPMENT OF MICROFLORA IN PRESERVES OF BALTIC SPRATS

(Vliyanie temperatury na khranieniya na razvitie mikroflory v preservakh iz baltiiskoi kil'ki)

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In the work carried out in the microbiological laboratory of the Leningrad Division of VNIRO in 1950-1951*, it was established that the viable microflora of fish preserves is represented by a number of physiological groups of microorganisms with different biochemical features. The connection between certain technological conditions of the preparation of preserves (the addition of preservatives and sugar) including the duration of their cold-storage on the one hand, with the bacteriological activity and stability of preserves on the other hand, was also shown.

The present work concerning the effect of storage temperature on the organoleptic features and on the development of microorganisms in preserves, is a continuation of the above-mentioned work.

The observations were carried out on two batches of sprat preserves, prepared according to the accepted technological instructions of the Ust'-Luga Fish plant in the spring and fall seasons.

The two batches of preserves were divided into two parts, one of which was stored in a cooling-house of the Krylov type at a temperature of 0° to minus $2^{\circ}C$, and the second in the laboratory refrigerator at a temperature of about $10^{\circ}C$. The temperature of $10^{\circ}C$ was chosen for the calculations, as in practice it was quite possible that storage would not be maintained at the accepted temperature of 0° to minus $2^{\circ}C$, but at another, depending on the season and on transport conditions.

The preserves were examined periodically during storage and subjected to chemical and microbiological analyses.

The microbiological investigations were carried out in order to assess the quantitative changes in the different groups of microorganisms during the storage period. We suppose that, on the basis of microbiological analysis, we may form an idea of the biological activity of microbes in preserves stored at different temperatures, and also of the connection between bacterial development and the activity of fermentative processes in preserves.

The organoleptic investigations indicated that storage at $10^{\circ}C$ accela ates the maturation process of preserves. The specific flavor and taste of the matured product and the softening of fish tissue in preserves stored at $10^{\circ}C$ occur more quickly than when stored at 0° to minus $2^{\circ}C$. Maturation occurs especially quickly

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* See the article by Yu.A. Ravich-Shcherbo and S.I. Ivanova, "The microbiological causes of decay in fish preserves and how to combat it." Proceedings of VNIRO Vol XX, Pishchepromizdat 1952.

in preserves made from sprats of the spring catches, in which the signs of maturation after cold-storage appeared only after 10-11 months; but when stored at 10°C, they appeared 35-37 days after preparation.

"Hypermaturation" of preserves is manifested by a sour taste, gas formation and "flaking" in brine. These phenomena appear sooner in warm-storage than in cold.

Swelling was not observed during cold-storage but occurred in some preserves during warm-storage. The stability of preserves from the same batch was not identical.

The microbiological investigations were carried out in order to determine qualitatively and quantitatively the group of microorganisms which caused changes in proteins and in sugar. We worked on the assumption that the maturation of preserves was caused by the accumulation of proteolytic products and was somehow stimulated by the addition of sugar. The microorganisms responsible for the fat changes, and which probably also influence the maturation process, were not studied in these investigations.

In order to isolate the above-mentioned microbes from the preserves, protein-containing media (fish-peptone agar, broth, milk agar) and sugar-containing media (glucose agar and broth, semiliquid agar and Taroszi medium) were inoculated with the brine. Special attention was paid to the salt-resistant microorganisms as, in our opinion, only such microorganisms can develop and cause biochemical changes.

In order to find the salt-resistant microorganisms, the inoculation was performed on fish-peptone agar which contained 12% salt, i.e., the same salt concentration as in brine.

Incubation was carried out for a week at a temperature of 24-26°C. After that the cultures were kept at room temperature for further observations.

When used to inoculate salt broth and agar, the brine samples, taken a day after the preparation of the preserves, gave a growth of salt-resistant microbes.

The fact that salt-resistant microorganisms were found in preserves at the beginning of storage is of great importance. It indicates that, among microorganisms introduced into preserves with the fish and other ingredients, are salt-resistant microorganisms. The successive changes in the quantity of microbes during cold and warm storage are indicated in Table L.

During cold-storage of preserves of both spring and fall catches the quantity of salt-resistant microbes gradually decreases and after 180-190 days of storage they are 15-20 times less than at the beginning. The successive observations carried out on the spring preserves indicated that the quantity of microorganisms decreases and, after 400 days of storage, we found only 2,000 microbes per one ml of brine.

Thus, according to our experiments, the salt-resistant microorganisms do not multiply in cold storage, but keep their vitality for some time and then gradually die off. Another picture was observed under warm storage of preserves. In the brine of spring preserves, the quantity of salt-resistant microbes greatly increases and reaches one million per 1 ml of cells by the 35th-37th day of storage. A similarly high increase in the quantity of microorganisms was also observed in the fall preserves, but they appeared at a later stage.

After the salt-resistant microbes were isolated into a pure culture and

Table I

The changes in the quantity of salt-resistant microorganisms in preserves during storage

Storage at 0 to −2°			Storage at 10°		
Storage in days	Quantity (in thousands) of microorganism cells in 1 ml brine		Storage in days	Quantity (in thousands) of microorganism cells in 1 ml brine	
	Spring preserves	Fall preserves		Spring preserves	Fall preserves
7—9	190	342	7—9	130	2384
35—37	—	120	16—18	256	2700
45—49	140	—	23	100	—
100	166	308	35—37	7342	229
120	195	—	45—49		38700
145	—	34	57—60	—	681900
168—178	90	17	85	—	331700
189	0	—	120	131200	—
238	—	151	168—178	147600	—
260	100	—	—	—	—
307	24	—	—	—	—
340	0	—	—	—	—
400	2	—	—	—	—

investigated in detail, it appeared that the salt-resistant microflora were not identical, but were represented by several species.

In cold storage preserves, and also in preserves stored for a short time in warm storage, they were generally represented by gram positive micrococci, which, in salted agar, yielded orange and straw-colored colonies.

The micrococci have a proteolytic ability and, inoculated into gelatin, gave a slow liquefaction but did not cause putrefactive decomposition of proteins. After inoculation into broth or milk, acid formation was observed. In their physiological features the micrococci were very similar to the Micrococcus aurantiens.

Another type of salt-resistant organism develops in preserves under prolonged warm storage. It was mentioned before that, after 37-38 days of storage or more, we observed a considerable increase in the quantity of salt-resistant microorganisms in preserves. They were identified as Streptoccocus citrovorus after using brine to inoculate agar.

The isolated microbes were odor-forming, had a considerable salt-resistance, and developed well in brine of a 16% salt concentration. The high salt-resistance was reinforced by the presence in the brine of substances which stimulated bacterial development. The dissolved nitrogen compounds, which accumulated as a result of fish protein decomposition, had such a stimulating ability. Therefore, the intensive development of microbes could also indicate a certain degree of protein decomposition.

It should be noted that the sharp increase in quantity of odor-forming microbes in spring preserves was accompanied by organoleptic signs of maturation. Upon further warm storage of preserves the development of these microbes was prolonged and after 35-60 days of storage, the taste of the preserves improved, and they took on the smell of the matured product. Therefore we may conclude that the

development of these microbes in the brine was the cause of the improvement in taste, and of the presence of flavor in preserves.

The development of odor-forming microorganisms was accompanied by an accumulation of acid in the brine which was found by organoleptic and chemical investigations of preserves. We confirmed this in a special experiment. The microbes were cultivated in sterile brine (the brine was first filtered through filter paper and then passed through a Seitz filter). During the experiment, the pH of the brine changed from 6.6 at the beginning of the experiment, to 5.0 at the end and, correspondingly, the acidity of the brine increased from 0.51 to 0.84%. We may presume that the formation of acid occurs as a result of sugar decomposition or deamination and decarboxylation of amino acids.

Simultaneously with the investigation of salt-resistant microorganisms, special attention was paid to the investigation of the presence of gas-forming microorganisms, which cause sugar fermentation under aerobic and anaerobic conditions. Aerobic microorganisms were found in small quantities in spring and fall preserves. At the beginning of storage, the titer was not more than 0.1 ml and, after 100 days of warm storage and 168 days of cold storage, no gas formation was observed upon inoculating into glucose broth. This points either to the death of such microorganisms or to a loss of gas-formation ability during storage. Such a loss of gas-formation ability was also observed upon cultivation of the earlier isolated gas-formers of the Bacterium coli type in a salt-containing medium.

The titer of aerobic gas-forming microorganisms in preserves not containing preservatives, is higher than in preserves with preservatives. Thus, we may suppose that the quicker swelling of preserves without preservatives and, consequently, the lower stability in comparison with preserves prepared with preservatives, are in some way connected with the activity of the aerobic microorganisms. Further observations confirmed that, in some conditions, the development of aerobic gas-forming microorganisms of the Bacterium coli type can be one of the basic causes of gas accumulation in preserves. It leads us to think that the titer of aerobic gas-forming microorganisms can, to some extent, indicate the quality of preserves.

The microorganisms which formed gas under anaerobic conditions, were represented in preserves by the Bacterium perfringens type. The titer of Bacterium perfringens in spring and fall preserves varied within the range of 1.0 to 0.1 ml independently of temperature and duration of storage.

The slight titer variations lead us to conclude that the temperature increase from minus 2° to plus 10°C had no effect on the activity of vegetative cells.

Probably, the observed titer changes reflected only the variations in the quantity of Bacterium perfringens spores. This is confirmed by the fact that after using brine to inoculate the Kitta-Tarozzi medium, and heating it to the point at which all cells should be killed, no considerable decrease in the microbial titer was observed. The activity of Bacterium perfringens was greater in preserves without preservatives. This can be explained by the greater activity of the putrefactive microorganisms, whose development is encouraged by Bacterium perfringens causing the alkaline reaction of the medium.

Hence, the activity of Bacterium perfringens did not change with the rise in the storage temperature of preserves, and was not greater in the swollen tins. Therefore, we should not consider the Bacterium perfringens titer as an indicator of the quality of sprat preserves.

CONCLUSIONS

The above-mentioned investigations allow us to form a conclusion concerning the microorganisms of sprat preserves and their activity changes at different temperatures, and also concerning the microbiological processes during maturation and spoilage of preserves.

1. Microorganisms introduced into preserves from various sources find different environments. These conditions are unfavorable for a large number of microbes because some factors which inhibit the development of most types of microorganisms (salt, preservatives, the hermetic sealing of tins) are present in preserves.

2. The addition of preservatives has a destructive effect on the gas-forming and putrefactive microbes, thus increasing the stability of preserves.

3. We did not find microbes in preserves which are able to develop at a temperature of lower than $0^{\circ}C$. The storage of preserves at a temperature of approximately $0^{\circ}C$ is accompanied by the gradual decrease in the quantity of microbes, but it does not prevent the possibility of some microbiological processes taking place in preserves.

At a storage temperature of approximately $10^{\circ}C$ the quantity of microorganisms present increases considerably. They are salt-resistant microbes with a distinct odor.

4. The increased activity of fish enzymes which occurs upon increasing storage temperature causes an increase in the protein decomposition process and an accumulation in the brine of nitrogen substances which stimulates the growth of odor-forming microorganisms, increases their resistance to unfavorable surrounding conditions, especially to the action of salt.

5. The salt-resistant microorganisms cause acid formation, which creates a lower pH favorable to enzyme activity. Simultaneously, the formation of acid inhibits the putrefactive processes and possibly gives with other substances, the specific taste of matured preserves.

6. Because the activity of the odor-forming microorganisms is accompanied by the formation of carbonic acid, we may suppose that the development of such microbes in preserves is one of the causes of the swelling of preserves. This was verified by the fact that, after active development of odor-forming bacteria in preserves, a swelling occurred after a certain time interval.

7. The accumulation of gas in preserves is not a result of the development of any one bacterial group, but is a combined result of the activity of different kinds of microorganisms and fish enzymes, and of gas-formation by the action of brine acids on the can. The swelling of preserves is a result of complicated biochemical processes which take place in preserves. The rate at which swelling takes place depends on the total number of internal factors affecting the condition of preserves (the activity of groups of microorganisms, intensity of fermenting processes) and of external factors connected with the state of the can (thickness, form, lids, and extent of filling of the cans).

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TECHNICAL CHARACTERISTICS OF VARIOUS FISH PRODUCTS

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The chemical composition and the nutritional value of many varieties of fresh and preserved fish have so far not been sufficiently studied. Literature on the subject contains hardly any information on the composition of smoked and salted products obtained from sprats and flatfish, nor on salted Atlantic and North Sea herring which has a notably great importance among the fish products turned out by the Baltic Basin enterprises. Similarly, very little has been ascertained regarding river and lake fish in the northwestern part of the USSR, among which the flatfish and the smelt are in great demand.

In connection with the above, the authors of this article have carried out analyses on a whole range of fish products in order to establish their nutritional value.

The test samples for this study were selected from among the following products: -

1) Hot smoked "salaka" [Clupea harengus membras L. - Clupeidae (herring family)]; 2) Hot-smoked sprat; 3) Hot-smoked flatfish; 4) spice-preserved Baltic sprat in jars (preserved in metal containers); 5) preserved Baltic sprat in barrels; 6) salted Atlantic herring; 7) salted North Sea herring; 8) Salted salmon; 9) Salted and dried smelt*; 10) Fresh Ladoga lavaret; 11) Fresh Ladoga "koryushka"**.

The selection and study of the test samples of the above mentioned fish products was carried out in accordance with the methods indicated in the handbook, "Methods of Study of the Composition of Indigenous Food Products", published by the USSR Academy of Medical Sciences in 1949.

The test samples were selected in fish-processing plants and commercial distribution centers from batches labelled Grade A. The samples of salted herring, preserved sprats in barrels, smoked "salaka", sprats, and flatfish, salted and dried "smelt" and fresh "koryushka" consisted of 1-2 kilos of each variety; the samples of fresh "lavaret" consisted of one to four specimens, depending on their size; of the sprats preserved in jars, two jars were taken in each case; the salted salmon were studied individually.

All the varieties of fish products, with the exception of the "smelt" were dissected before analysis, thus taking into account the edible portions meat or trunk and the waste (heads, fins, internal organs, skin and bones).

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* European smelt ("snetok") [Osmerus eperlanus eperlanus morpha Spirinchus Pallas], referred to in text as "smelt".

** Ladoga smelt ("koryushka") [Osmerus eperlanus eperlanus natio ladogensis Berg] referred to in text as "koryushka". - Editor's note.

In the case of salmon, lavaret, herring, flatfish and "salaka", the meat was subjected to chemical analysis; in the case of sprat, the trunk was analyzed; "smelt" was analyzed in its entirety; in the case of the "koryushka" both the whole fish and the meat were analyzed.

In the course of the chemical analysis the following contents were determined: moisture, fat, protein, total quantity of mineral substances (ash content) and individual mineral substances, i.e., calcium, potassium, phosphorus, magnesium and iron.

In addition to the authors of this article, B.A. Kosarev, G.L. Kreitser, and M.N. Semenov participated in the analytical work:

Listed below are the results of study of the fish products.

"Salaka" [Clupea harengus membras L.] Hot Smoked

The test samples of smoked "salaka" were selected in June and September, 1950, from the Ruch'ev fish distribution center of the Lenryba trust, the fish having been caught in Kapor Inlet in the Gulf of Finland. Each sample batch consisted of 30 small fish. The weight of the test samples of the spring catch was 10-20 g (average 14.1 g), and of the fall catch, 15-25 g (average 20g).

The yield of dissected body parts of smoked "salaka" prepared in spring was as follows (in percent of the weight of the whole fish):

Meat - 50.7; skin - 7.3; head - 14.1; roe - 11.3; milt - 6.7; remaining viscera - 7.8.

In the case of the smoked "salaka" herring prepared in the fall, only the yield of the meat and the sexual products was taken into account; thus the weight of the meat comprised 62.8%, and that of the sexual products, 9.1% of the total weight of the whole fish.

Since the roe and the milt, together with the meat of the "salaka" smoked in the fall are used for food, its edible content (71.9%) is actually somewhat higher than that of "salaka" herring of the spring (68.7%).

Results of the chemical analysis of the meat of smoked "salaka" are given in Table I.

The chemical composition of the meat of smoked "salaka" prepared in June and September did not show any substantial differences.

The relatively low fat content found in the meat of the "salaka" prepared in autumn is an important feature. From the data of analyses carried out in 1949, the fat content of smoked "salaka" of the December catch was considerably higher, and constituted 10.5-13.6% (on the average, 11.9%).

The variations in fat content occurring in smoked "salaka" depend to a certain extent on the nature of the smoking process insofar as it is connected with the extent of moisture elimination from the product. As can be observed from Table I, the "salaka" prepared in September contained more moisture than that prepared in June. On conversion of the given data to dry fish substance, the

fat content of the September catch equaled 17.6-18.2% (average 17.9%), while in the smoked "salaka" of the June catch, it comprised 14.0-14.6% (average 14.4%).

Table I

Chemical composition of hot-smoked "Salaka" meat

Season of preparation	General chemical composition in %					Content of mineral elements in mg per 100 g				
	Moisture	Fat	Protein (Nx6.25)	Ash	NaCl	Ca	K	Mg	P	Fe
June	61.32	5.30	25.90	4.36	3.27	60.9	430,7	51,1	357,0	4,6
	64.26	5.03	26,12	4.37	3.51	66.0	466,9	65,1	353,7	3,9
	64.17	5,12	26,06	4,49	3.51	65.5	456,2	64,2	357,0	3.6
	61,54	5.39	27.58	5,28	4,19	67.2	452,7	61,3	390,5	4,0
	61.63	5.62	27,50	4.95	3,95	64,2	431.9	51,1	364,5	3.8
Average..	62.58	5,29	26,63	4,69	3,69	64.8	447.6	58,5	364.5	4,0
September	66.25	5.95	24,23	3,39	2.51	41.2	431,2	42,6	336,4	2,2
	66,03	6.00	24,80	3,21	2.27	39.0	419,8	55,5	336,9	2,5
	66,09	6,17	24,30	3,10	2,15	41,5	425,2	55,5	334,2	2,0
	66,60	5,98	24,37	2,92	2,03	40, 6	415,8	55,5	325,2	2.0
	67.39	5.98	23,37	3,02	2,03	44,5	114.8	49,6	328,0	2,5
Average...	66,47	6,02	24,21	3.12	2.20	41,3	121.3	51,7	332,1	2,2

Sprat [Sprattus sprattus balticus Sch.] Hot Smoked

This variety is produced in considerable quantities in the Estonian SSR enterprises during the fall. The meat of the smoked sprat from the Gulf of Findland, caught in September, October and November was analyzed.

Table II

Chemical compositions of hot-smoked sprat meat

Date of the processing of the product (1950)	General chemical composition in %					Content of mineral elements in mg per 100 g				
	Moisture	Fat	Protein (Nx6.25)	Ash	NaCl	Ca	K	Mg	P	Fe
7/IX	67.80	7.54	21.66	2,50	1,46	120,0	292.0	70,0	295.0	4.0
	68,66	7,14	21.31	2.42	1,36	112.0	294,0	45.0	292.0	4.2
	67.98	7.34	21.31	2.67	1,75	104.0	298,0	76.0	286,0	3,6
13/IX	68.00	7.54	21.38	2,65	1.60	130,0	242,0	50,0	290.0	4,4
	62.20	8.91	25,34	3.09	2.05	112,0	265.0	44,0	324.0	3,6
Average . . .	66,93	7.69	22,19	2,70	1,64	116.0	278.0	57,0	297.0	4,0
2/X	66.50	8.28	21.56	3.04	1,91	120,0	299,0	42.0	294,0	2.4
3/X	67,10	8.65	21,10	2,67	1,70	112,0	225.0	42,0	240.0	3,1
5/X	65,60	8.05	22.43	3.64	2.42	104,0	335,0	44.0	288,0	3,6
25/X	67,55	9.12	19.44	3.28	2,18	94.0	372.0	58.0	288,0	3,5
Average . . .	66.70	8.52	21.13	2.90	2,05	107.5	308,0	46,5	277,5	3.2
1/XI	67.35	10.06	19,13	3,11	2,08	104.0	344,0	45,0	269,0	3,3
1/XI	65.72	11.14	19,50	3,26	2.22	104,0	346,0	44,0	281.0	2.9
Average . . .	66,53	10,60	19,31	3,18	2,15	101,0	345.0	44,5	275,0	3,1

The data of analyses given in Table II indicate that the fat content of smoked sprat meat increases from 7-8 % to 10-11 % in the period from September to December while the protein content decreases from 22.2 % to 19.3 %.

River Flatfish [pleuronectes flesus] Hot-smoked

Samples of flatfish caught in the Gulf of Riga during the period from the end of May to the beginning of September and processed in the Ventspils Fish--canning Plant, were analyzed.

The weight ratio of the different body parts of smoked flatfish, is indicated in Table III, while Table IV gives the results of the chemical analysis of its meat.

From the data contained in Table III one can see that the relative weight of the meat of flatfish smoked in the fall is not much greater than that of the spring and summer catches, while the amount of roe and milt is less. The total quantity of edible parts, including the meat and the sexual products, of a smoked flatfish of the June catch constitutes, on the average 44.6 %, of the July catch 46.7 %, and of the September catch 47.8 %.

Table III

Weight relations between points of hot-smoked flatfish

Date of processing of the product (1950)	Number of specimens tested	Length of fish in cm	Average weight of fish in gr	In % of the whole fish weight					
				Meat	Head	Entrails	Skin	Fins	Bones
3/VI	—	—	—	42.2	22.0	4.2	14.1	5.0	12.2
4/VI	—	—	—	42.8	21.7	4.6	14.3	4.6	12.0
5/VI	—	—	—	37.0	22.5	3.0	17.5	3.5	16.5
10/VII	10	21.0—25.0	136.0	47.8	18.5	3.3	13.2	4.4	12.5
11/VII	12	19.0—26.0	125.0	38.5	21.3	4.0	19.0	5.3	16.6
9/IX	7	24.0—30.5	143.0	41.5	25.5	2.0	15.5	4.5	10.0
9/IX	6	25.0—31.0	167.0	44.5	26.0	1.8	13.0	5.0	9.4
11/IX	6	28.0—42.0	143.0	41.0	25.0	3.0	16.0	4.0	11.0
11/IX	7	25.0—35.0	167.0	48.5	21.0	2.5	13.0	5.5	9.5
11/IX	7	26.0—30.0	167.0	48.5	29.0	1.5	14.0	3.0	10.0
		Average		43.2	23.2	3.0	15.0	4.5	12.0

The chemical composition of the meat of smoked flatfish depends on when it is caught. The fat content in the meat of smoked flatfish caught in Spring (May) constitutes on the average 5 %, while in the summer-fall season (July to September) it reaches 11-12 %. The fat content varies according to changes in the moisture content of the meat. The smoked spring flatfish contains 68-69% moisture, while those caught in the summer and fall contain 63-64 %; the protein content of the meat remains constant, constituting an average of 22 %.

Sprat [sprattus sprattus balticus Sch.], Spice-preserved in Jars

Samples of preserved "Tallin" and "Baltic" sprats were selected in the fish-processing plants of the Estonian and the Latvian SSR, and taken for analysis. Two jars were taken for examination in each case.

Table IV

Chemical composition of hot-smoked flatfish meat

Date of processing of the product (1950)	General chemical composition in %				Content of mineral elements in mg per 100 gr				
	Moisture	Fat	Protein (N×6,25)	Ash	Ca	K	Mg	P	Fe
29/V	68.90	4.30	22.80	3.60	—	—	—	—	—
	68.60	4.40	24.00	2.60	137.5	417.0	40.0	—	3.3
	67.60	5.90	—	3.90	—	—	—	—	—
Average	68.30	4.90	23.40	3.90	137.5	417.0	40.0	—	3.3
7/VII	63.50	12.10	21.50	2.50	177.0	238.0	29.5	291.0	2.3
	63.90	12.20	21.20	2.90	140.0	459.0	34.5	236.0	3.2
Average	63.70	12.20	21.40	2.70	158.5	348.0	32.0	263.5	2.7
6/IX	64.00	10.50	22.00	3.30	134.0	411.0	32.3	261.0	5.7
	59.40	14.20	22.60	3.10	138.0	322.0	35.3	276.0	3.0
	63.00	10.70	22.00	3.80	105.0	205.0	42.3	290.0	5.0
	63.30	10.80	21.90	2.90	86.0	210.0	—	213.0	5.5
	63.90	10.60	22.70	2.60	103.00	200.0	52.4	240.0	7.0
Average	62.70	11.40	22.20	3.10	113.0	270.0	40.6	296.0	5.3

The size of the fish in individual jars varies from 7 to 15 cm, and the weight of each fish, from 5 to 17 g. In the process of dissection, the trunk yield constituted from 71.7 to 79.0%, and averaged 75.4% of the total weight of the entire fish.

Results of the chemical analysis of the fish trunk are given in Table V.

Table V

Chemical compositions of bodies of spice-preserved sprats in jars

Date of processing of the product (1950)	General chemical composition in %					Content of mineral elements in mg per 100 gr				
	Moisture	Fat	Protein (N×6,25)	Ash	NaCl	Ca	K	Mg	P	Fe
	Tallin sprats									
22/VI*	65.72	8.13	14.68	11.00	9.86	278.0	332.0	58.2	301.0	4.7
3—4/X**	62.26	11.68	14.87	10.62	9.40	279.0	372.0	37.0	280.0	4.1
6—7/X**	62.36	11.01	14.66	11.42	10.12	307.0	352.0	41.0	297.0	3.4
30/X	62.15	12.58	14.38	10.28	9.10	367.0	367.0	47.0	304.0	2.5
	Baltic sprats									
8/II***	59.60	13.00	17.70	9.70	Undetermined	170.2	278.7	67.9	129.0	4.3
30/V****	65.30	9.70	15.70	9.40	9.10	347.9	220.5	41.9	204.9	4.6
30/IX**	60.65	14.05	15.95	11.00	10.65	220.9	259.1	22.2	228.2	4.8
13/X	61.30	12.20	14.50	11.20	10.80	187.8	277.6	18.0	166.1	1.6
16/X	62.30	12.10	14.20	10.90	10.00	221.9	297.5	22.8	208.4	3.9
23/X	61.30	13.70	14.60	10.40	10.70	186.1	306.0	26.4	148.1	3.5

* Average data of analysis, 5 tests
** " " " 2 "
*** " " " 4 "
**** " " " 5 "

It was observed that the fat content (of the trunk) of fish preserved in spring (May to June), was considerably lower (8.1 to 9.7%) than in fish preserved in the fall (September to October), and in winter (February) (11.0 to 14.0%). The protein content of the trunk of fish preserved in winter (17.7 %) was also higher than that preserved in the spring and fall (14.2 to 15.9%).

Sprat [sprattus sprattus balticus Sch.] Preserved in Barrels - Salted

Test samples were selected from two batches of salted spring and fall sprats. The sprats were caught in the Gulf of Riga, underwent a simple processing operation in the spring, and a further spice-processing operation in the fall. A few samples of salted sprats were taken from the barrels of several batches.

The size of the fish in the individual samples did not differ greatly, varying only from 9.5 to 13.5 cm; the average weight of the fish in the spring samples was about 8 g and in the fall samples, 9.5 to 10 g.

The weight of the trunk in relation to the weight of the whole fish varied in different cases from 74 to 78% and averaged 75.5%. The chemical composition of the salted sprats is tabulated in Table VI.

Table VI

Chemical composition of barrel-salted sprats

Test number	Date of processing (1950)	General chemical composition in %					Content of mineral elements in mg per 100 gr				
		Moisture	Fat	Protein (Nx6,25)	Ash	NaCl	Ca	K	Mg	P	Fe
	Sprats of simple salting										
1	5/V	55.3	—	21.4	11.6	Not determined	286.4	401.5	100.0	—	—
2	5/V	52.2	13,0	23.0	11.1		243.4	198.5	83.9	—	4.6
3	5/V	55.4	12,1	—	11.6		239.9	247.6	43.6	—	8.5
	Average	51.3	12,5	22.2	11.4		256.6	280.9	75.8	—	6.5
	Salted sprats with spices added										
1	21/X	58.5	14.3	15.3	11.0	10.1	152.3	306.9	29.4	212.3	3.9
2	21/X	58.7	13.9	—	10.6	10.1	201.1	305.7	18.7	273.3	3.6
3	21/X	58.6	14.2	16.9	10.6	10.0	206.6	322.0	31.8	184.8	3.5
4	21/X	58.3	14.5	15.9	10.1	10.1	222.2	324.8	23.7	202.7	4.7
5	21/X	57.4	15.5	16.7	10.4	9.7	218.7	270.9	31.8	166.1	2.5
	Average	58,3	14,5	16.2	10,5	10.0	200.2	306.0	27.1	207.8	3.6

It is of interest to note that the moisture content of the trunk of the salted sprats in barrels is noticeably less than that of the spice preserved and salted sprats in jars, while the protein and fat content of the trunk of the former variety, is higher than that of the latter variety (see Table V). The degree of saltiness in both varieties was practically identical.

Atlantic and North Sea Herring [Clupea harengus harengus L.], Salted

The samples of salt herring for examination were selected from vessels delivering the processed product from the fishing grounds in the Norwegian Sea and in the North Sea during the summer fall season of 1951.

Table VII indicates the size of the salted herring samples, and the weight ratios of the different parts of the body.

It can be seen from the data given in Table VIII that the meat of the salted Atlantic herring of the summer catch (July to August) contains an average of 51.0% of moisture, 13.4% of fat, 19.8% of protein, and 16.2% of ashes. The meat of the North Sea herring of the summer fall catch (July to November) surpasses the salted Atlantic herring of the summer catch in nutritional value; the fat content of the meat of this herring reaches 23%, having an average of 20.6%, while the protein content averages 18.0%, and the ash content 15.6%.

it is of interest to note that the contents of calcium, potassium, magnesium and iron in the meat of both varieties are similar, while the phosphorus content of the salted Atlantic herring is almost twice that of the North Sea herring.

Table VII

Size and weight composition of salted herring

Test number	Date of processing (1951)	Number of fish specimens in the test	Average weight of fish in gr	Weight relation of separate parts of the fish in % of the total weight of the whole fish				
				Meat	Head	Entrails	Skin and fins	Bones
	Atlantic Herring							
1	13/VII	5	282	57.5	16.3	11.5	7.0	5.5
2	15/VII	5	322	58.0	15.2	14.0	6.5	4.5
3	5/VIII	5	265	58.0	16.4	10.7	8.2	4.8
4	6/VIII	5	288	58.3	15.3	11.8	7.4	5.0
5	8/VIII	5	290	58.0	16.0	11.6	7.1	4.9
Average			289,0	58,0	16,0	11,9	7,2	4,9
	North Sea Herring							
1	Июль	9	116	58,8	16,8	10,4	7,5	4,4
2	12/IX	13	136	59.3	14,7	14,5	8,5	4,2
3	10/X	12	111	58,0	15,3	13,4	6,4	4,3
4	26/X	7	183	53,0	14,0	21,0	6,8	4,7
5	1/XI	8	172	53.3	14,6	19,2	7,0	4,6
Average			144	56,5	15,1	15,7	7,2	4,4

Salmon [Salmo salar L.], Salted

Five samples of salted salmon were selected for examination at the Glavryba Center No 2 in Leningrad. According to the markings and labels, these small salmon were salted in the period from June 8 to 12, 1950, in the Umbozero Lake Fish Processing Plant of the Kol'Gosribtrest.

Table VIII

Chemical composition of salt herring meat

Test number	Date of processing (1951)	General chemical composition in %					Content of mineral elements in mg per 100 gr				
		Moisture	Fat	Protein (N×6,25)	Ash	NaCl	Ca	K	Mg	P	Fe
	Atlantic Herring										
1	13/VII	52.06	12.74	19.02	16.70	15.90	124.2	268.3	35.6	348.7	6.6
2	15/VII	50.28	14.46	20.55	15.67	15.11	118.3	—	—	253.0	—
3	5/VIII	51.02	11.10	21.06	16.80	16.20	98.1	—	—	317.5	—
4	6/VIII	52.15	13.14	18.42	16.14	15.52	99.9	281.7	39.6	374.8	6.2
5	8/VIII	49.28	15.45	20.07	15.75	15.05	93.7	—	—	343.1	—
	Average	51.02	13.38	19.82	16.25	15.59	106.8	275.0	37.6	347.6	6.4
	North Sea Herring										
1	July	42.50	18.89	21.07	16.44	15.87	138.0	297.4	49.7	185.9	4.1
2	12/IX	42.84	23.03	19.27	15.20	14.61	136.9	280.5	46.8	172.4	1.2
3	10/X	43.08	23.38	17.57	15.84	15.26	136.2	283.9	45.5	186.8	1.6
4	24/X	52.90	19.14	14.66	13.99	13.44	138.0	—	—	185.2	—
5	1/XI	46.63	18.79	17.84	16.88	16.35	136.2	—	—	197.6	—
	Average	45.39	20.66	18.08	15.67	15.10	137.0	287.3	47.3	185.6	2.3

From the time of the actual processing until its examination, the fish were kept in storage for about 2 months.

Data on the weight and chemical analysis of the salmon is given in Tables IX and X.

Table IX

Weight relation of separate parts of the salmon

Test number	Weight of fishing	In % of the weight of fish			
		Meat	Head	Skin	Bones
1	1825.0	69.9	15.9	7.1	6.8
2	1890.0	74.1	13.2	5.8	6.6
3	1900.0	71.8	13.9	6.0	7.9
4	2200.0	74.6	11.8	6.9	7.0
5	2230.0	73.8	12.8	6.3	6.7
Average		72.8	13.5	6.2	7.0

Table X

Chemical composition of salted salmon meat

Test number	General chemical composition in %					Content of mineral elements in mg per 100 g				
	Moisture	Fat	Protein (NX6.25)	Ash	NaCl	Ca	K	Mg	P	Fe
1	55.61	12.17	22.68	9.36	8.86	34.8	216.0	61.3	250.0	2.0
2	55.37	13.00	22.80	8.74	7.90	39.3	229.0	58.4	276.0	3.2
3	57.24	11.02	23.20	8.42	7.51	43.3	238.0	60.7	230.0	2.3
4	59.00	10.08	23.15	7.65	7.18	42.4	239.0	63.1	240.0	2.2
5	59.20	8.56	22.00	10.15	9.70	41.8	184.0	65.0	250.0	3.1
Average	57.28	10.97	22.76	8.84	8.29	40.3	221.0	61.7	243.0	2.5

In accordance with the results of the analysis, the amount of meat in the small salted salmon averaged about 73% of the total weight of the whole fish. However, in spite of the fact that all the salmon were caught in the same region, at the same time, and were of similar size, the fat content of the meat of the individual samples varied considerably, ranging from 8.5% to 13%, (an average of 11%). The protein content in the meat constituted 22-23%, and that of ash approximately 9%.

European smelt [Osmerus eperlanus eperlanus morpha Spirinchus Pallas] salted and dried

The samples of salted and dried European smelt were selected from Glavrybtorg No 2 in Leningrad, the fish having been caught in the Gdov Lake during the middle of May, 1950, and processed by the Gdov Fish Processing Plant, a branch of the Pskov Gosrybtrest. From the time they were caught until examination the fish were stored for a little over a month. The samples were selected from different packages, the average weight of the individual fish being 0.4–1.3 g.

Results of the analysis are given in full in Table XI.

Table XI

Chemical composition of ~~dired~~ dried salted smelt (whole)

Test number	General chemical composition in %					Content of mineral substances in mg per 100 g				
	Moisture	Fat	Protein (NX6.25)	Ash	NaCl	Ca	K	Mg	P	Fe
1	40.69	3.46	34.30	21.37	16.54	1590.0	460.0	83.2	1071.0	8.0
2	44.62	2.97	30.31	21.83	17.10	1402.0	363.0	112.4	992.0	6.0
3	41.06	3.48	33.26	22.00	16.42	1425.0	409.0	70.8	1066.0	5.9
4	44.62	2.83	29.56	22.83	16.66	1442.0	389.0	110.0	1014.0	6.5
5	41.39	3.21	32.60	22.52	17.38	1481.0	409.0	116.8	1056.0	8.6
Average	42.47	3.19	32.06	22.11	16.82	1468.0	406.0	98.6	1040.0	7.0

As can be seen from Table XI, the salted and dried European smelt had an extremely high protein content of 30 to 34 % (an average of 32 %); the fat content (not high) was approximately 3 %.

The lavaret [Coregonus lavaretus], Fresh

Samples of lavaret, caught in Lake Ladoga in July and October, 1951, were examined.

The weights of the lavaret samples examined are tabulated in Table XII.

Table XII

Weight relation of body parts of fresh "lavaret" [Coregonus lavaretus]

Test number	Date of catch (1951)	The number of types of fish in test	Length of fish in cm	Average weight of fish in g	Weight composition in %							
					Meat with skin	Head	Roe	Milt	Other entrails	Scales	Fins	Bones
1	14/VII	2	34—36	387.5	67.8	10.7	0.6	—	9.8	1.9	1.0	6.8
2	14/VII	2	37—38	540.0	69.2	9.7	0.5	—	10.2	2.8	0.9	5.2
3	14/VII	2	39—40	647.5	66.8	9.6	3.1	—	10.7	2.3	0.8	6.2
4	14/VII	2	44—46	990.0	70.7	9.3	—	0.9	9.6	2.3	0.8	5.5
5	14/VII	2	50	1215.0	68.7	10.9	0.4	0.3	10.5	2.5	0.8	6.2
	Average				68.6	10.0	1.1	0.6	10.2	2.4	0.9	6.0
6	13/X	1	32	265.0	67.8	12.5	None	0.7	7.6	1.9	0.7	6.8
7	13/X	1	35	320.0	70.9	9.4	None	0.9	6.2	3.1	1.6	6.2
8	13/X	4	36—37	425.0	69.1	10.0	4.2	0.9	5.3	2.1	0.9	6.2
9	13/X	4	39—40	577.5	67.1	11.6	2.8	0.9	5.8	2.6	1.1	6.3
10	13/X	4	44—56	750.0	63.5	13.3	6.2	6.6	4.7	2.7	0.9	6.0
11	13/X	2	49—50	1070.0	60.7	10.3	13.8	—	5.0	2.6	0.9	5.4
	Average				66.5	11.2	6.7	2.0	5.7	2.5	1.0	6.1

The above Table does not reveal any substantial dissimilarity in the respective weights of lavaret caught in July and in October. The lavaret is a fleshy fish, the meat averaging 66-68 %, the head 10-11 %, the bones approximately 6 %, the scales 2.5 %, and the entrails 12-14 % of the total weight of the whole fish.

The chemical composition of the meat of the lavaret is given in Table XIII.

The lavaret varies considerably depending on the fat content of the meat which in turn is related to the size of the fish and the season of its catch. In summer the lavaret has a higher fat content than in the fall, the larger specimens having a higher fat content than the smaller ones in both seasons. In summer (July) the lavaret contains an average of 9.5 % of fat, while in the fall (October) it contains about 7 %. The protein content of the meat constitutes 19-20 %.

The meat of fall fish samples was found to contain a large amount of mineral elements, particularly calcium. This is explained by the fact that in the processing

of the spring samples, the meat is completely separated from the ribs, while in the processing of the fall samples, the ribs are left in the fillets.

Table XIII

Chemical composition of lavaret meat

Date of catch (1951)	Length of fish in cm	General Chemical Composition in %				Content of Mineral Elements in mg per 100 g				
		Moisture	Fat	Protein (NX6.25)	Ash	Ca	K	Mg	P	Fe
14/VII	34—36	73,47	6.88	18.87	1.01	—	—	—	225.6	—
14/VII	37—38	71.22	9.48	19.12	1.14	52.7	326.6	30.6	236.7	1.8
14/VII	39—40	71.75	8.50	19.50	1.12	70.0	328.0	30.6	230.6	1.9
14/VII	44—46	68,86	11.01	19.87	1.16	56.7	326.9	33.1	—	1.7
14/VII	50	65,00	12.16	21.50	1.16	64.70	321.3	34,0	228,0	1.7
Average.		70,00	9.61	19,77	1.12	61,02	325,7	32,1	230,0	1.8
13/X	32	72,36	7.37	18.87	1,32	131,5	514.4	24.5	245,0	2.9
13/X	35	72,05	6.91	19.62	1,37	113.5	517.9	25.5	255,0	2.7
13/X	36—37	73,46	6.67	18.68	1,31	109.5	522.2	26.8	240.4	2.5
13/X	40	73,90	5.90	18.81	1,30	116.5	513,0	27.2	278.0	1,7
13/X	44—45	73,74	6.36	18.43	1.44	144.0	517.0	26.3	255.0	1.5
13/X	49—50	72,28	8.61	18.00	1.29	137.5	528,6	24.5	238.0	1.4
Average .		72.96	6,97	18.73	1,34	125.4	523.3	25.8	252,0	2.1

"Koryushka" Ladoga Smelt [Osmerus eperlanus eperlanus natio ladogensis Berg], Fresh

Samples of "koryushka" caught in Lake Ladoga in April and May 1951, were selected for examination. The weight of the April variety ranged from 6.1 to 41.7 g (average 16.1 g), and of the May variety, from 3.7 to 29.7 g (average 8.7 g).

Data on the weight of the "koryushka" samples is given in Table XIV.

Table XIV

Weight relation of body parts of fresh "koryushka"

Date of catch (1951)	Number of specimens in test	Length of fish in cm	Average weight of the fish in g	In % of fresh fish weight					
				Meat	Head	Roe	Milt	Other entrails	Bones
24/IV	807.0	10.5—19,5	16.1	50,4	17,8	9.8	1.2	8.6	8.2
26/V	436.0	9.5—18,7	8.7	55.0	20.3	2.5	0.5	8.2	11.0
	Average.			52,7	19,0	6,2	0.8	8.4	9.6

The meat yield of the April variety was somewhat lower (50.4%) than that of the May variety (55%), this difference being explained by the presence of a larger quantity of sexual products in the April variety in comparison with the May variety. In as much as the Ladoga "koryushka", as concerning the lavaret, is used mainly in the preparation of salted and dried products, its nutritional value can only be assessed after studying the composition of the entire fish and not just the meat alone. With a view to such an assessment the "koryushka" was subjected to chemical analysis of the meat separately, and of the fish in its entirety.

The data of these chemical analyses is given in Table XV.

Table XV

Chemical composition of "Koryushka"

Date of catch (1951)	General chemical composition in %				Component of mineral elements in mg per 100 g				
	Moisture	Fat	Protein (NX6.25)	Ash	Ca	K	Mg	P	Fe
			Whole "Koryushka"						
24/IV	76.34	4.47	15.93	2.30	429.0	326.0	32.9	—	1.6
16/V	80.13	1.89	15.00	2.50	567.0	310.0	27.0	—	2.1
21/V	79.55	2.10	15.25	2.42	585.0	303.0	33.3	503.0	2.4
27/V	79.78	2.11	15.50	2.57	693.0	313.0	33.0	475.0	2.2
Average .	78.95	2.64	15.42	2.45	568.0	313.0	31.5	489.0	2.1
			"Koryushka" Meat						
24/IV	79.19	1.93	18.00	1.26	129.0	276.0	25.0	212.0	1.7
16/V	80.91	0.96	16.68	1.21	125.0	250.0	23.0	220.0	1.7
21/V	80.56	0.99	17.00	1.20	123.0	276.0	26.0	241.0	1.8
27/V	81.15	0.83	16.87	1.21	140.0	249.0	—	205.0	2.2
Average .	80.45	1.18	17.13	1.22	129.0	263.0	25.0	219.0	1.8

As indicated in Table XV, the fat content of the "koryushka" notably decreased in the period from the end of April to the end of May, the fat content of the whole fish decreasing from 4.47% to 2.11% in the same period, and that of the meat from 1.93% to 0.83%. The protein content of the whole fish averaged 15.4%, and that of the meat, 17.1%, while the ash constituted 2.4% and 1.2% respectively.

CONCLUSIONS

The studies described above enabled us to assess the nutritional value of certain varieties of fish products, to which very little study had been previously devoted. Based on the data obtained on the fat and protein contents of the fish products, the average calorific value was calculated in the usual manner, as indicated in Table XVI.

Table XVI

Calorific value of analyzed fish products in calories per 100 g of edible part

Serial No	Name of fish product	calorific value	Serial No	Name of fish product	Calorific value
1	"Salaka" herring hot-smoked (meat)	155	6	Atlantic herring, salted (meat) - summer	206
2	Fall sprat hot-smoked (meat)	166	7	North Sea herring salted (meat) - summer	266
3	Spring flatfish, hot-smoked (meat)	144	8	Smelt, salted and dried (whole)	195
	The same, summer fall	199	9	Lavaret, fresh, from Lake Ladoga - summer	161
4	Spring sprat, spiced, salted, in jars (trunks)	145	10	Lavaret, fresh, from Lake Ladoga -summer	137
	The same, fall	177		The same, fall	142
5	Spring sprat spice-salted, in barrels (trunks)	207	11	"Koryushka", fresh, from Lake Ladoga (whole)	88
	The same, fall	201		The same, (meat)	81

Table XVII

Average content of mineral elements in fish products

Name of fish product and of analyzed part	Content in mg per 100 g				
	Ca	K	Mg	P	Fe
"Salaka", hot-smoked (meat)	53	434	55	334	3.1
Sprat, hot-smoked (meat)	111	301	51	286	3.5
Flatfish, hot-smoked (meat)	127	304	38	287	4.4
Sprat, spice-salted in jars (trunks)	256	306	38	227	3.7
Sprat, spiced, barrel-salted (trunks)	221	297	45	208	3.8
Atlantic herring, salted (meat)	107	275	38	348	6.4
North Sea herring, salted (meat)	137	287	47	185	2.3
Salmon, salted (meat)	40	221	62	243	2.5
Smelt, dried and salted (whole)	1468	406	98	1040	7.0
Lavaret, fresh (meat)	61	326	32	230	1.8
"Koryushka", fresh (whole)	568	313	31	489	2.1
" " (meat)	129	263	25	219	1.8

As may be observed, with the calorific value of the examined fish products as the criterion, these products have proved to be highly nutritious. However, in accordance with the current viewpoint, the nutritional value of various food products, including fish, is determined not only on the basis of their protein and fat content, but also by the presence of various mineral elements. From this point of view, the established content of mineral elements in fish products is of significant value. Table XVII indicates the average content of mineral elements in the examined fish products as follows: calcium, potassium, magnesium, phosphorus, and iron.

A comparative study of the content of the mineral elements of various fish products presents some difficulty owing to the amounts of water and sodium chloride used during the processing operations. However, the order of magnitude which characterizes the quantity of individual mineral elements present in various products, testifies to a certain correlation. Thus, the magnesium content of the meat or trunk of the examined varieties of salted and smoked fish constituted 38-62 mg%; the iron content 2.3-6.4 mg%, that of phosphorus - 185-348 mg%; and of potassium - 221-434 mg%. Considerable variations are observed in the calcium content; this is due to the presence of the bones in the examined products. In cases where the fish meat under examination was adequately freed of the ribs and the intermuscular bones, the calcium content was found to be 40-137 mg%; the calcium content however was far higher in the salted fish trunks - more than 200 mg%, and in the fresh whole fish and in the salted and dried fish - 570 mg% and 1,470 mg% respectively. A higher phosphorus content - 490-1,040 mg% corresponded to the higher calcium content in the whole fish.

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TECHNOLOGICAL FEATURES OF ANTARCTIC WHALES AND EFFICIENT METHODS FOR THEIR UTILIZATION

(Tekhnologicheskaya kharakteristika kitov Antarktiki i ratsionalnye sposoby ikh ispol'zovaniya)

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During the years 1948-55 investigations were carried out in VNIRO on the technochemical properties of different body parts and organs of whales. The most efficient methods for utilizing the whale body were also studied.

As a result of these experiments, a cold method for extracting the subcutaneous blubber was found. This method enables the protein parts to be preserved for leather and gelatin production. The technology of dry protein production from whale meat, and the complex method of utilizing whale liver for vitamin A, campolon*, and protein cattle fodder were proposed as well. A number of drugs and other commercial substances, e.g., insulin, cortisone, ACTH, pancreatin, lecithin, and cholesterol were also obtained from the whale's endocrine glands and brain.

Having based our work on a better knowledge of the characteristics of the raw whale material, we studied all types of antarctic whales, (finback whale, sulphur-bottom (blue) whale, humpback whale, and sperm whale). But in general, attention was paid to the basic types of antarctic whales, the finback whale and the humpback whale. The results of our investigations on the weight and chemical composition of separate body parts and organs of the finback whale have been partially reported previously /6/. In this work we supply new information on the chemical composition of different types of raw whale material, and the established average production output of different body parts in different types of whales during preparation. We also record the general scheme for efficient processing of whalebone whales and sperm whales, together with the probable output of various products from their bodies.

Method of Investigation

The weight ratio of separate parts of the whale's body was established and the chemical analysis made aboard the whaler "Slava" during the processing of the whales, separate parts of the carcass being weighed with the aid of a dynamometer connected to a derrick.

To separate the blubber, meat, fins, heart, and lungs we used the above-mentioned method /8/. Bone samples were sawn from the vertebral column with a steam saw and, at first, on measuring the length of the vertebral column, we determined the approximate distance between its cerebral and caudal portions, thereby establishing that the caudal portion is from 65% (humpback and sperm whales) to 75% (finback and sulphur-bottom whales), of the total length of the vertebral column /15/. Pieces 10-15 cm long were taken from both cerebral and caudal portions.

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* [Campolon: anti-anaemia drug prepared from the liver of sea mammals - campolon MZH. Translator's note].

Samples of the ribs were obtained in the following manner: every second rib was chosen from one side of the thorax (total: 5-6 ribs), and, from the middle of each rib was cut a piece 10-15 cm long. The skull bone samples were taken in the form of sawdust obtained during the cutting of the skull bones.

Samples were taken from the beginning, middle and end of the stomach.

Samples of the small intestine, 10-15 cm long, were taken at a distance of 1 m from the stomach.

Samples from the large intestine were taken 1.5 m from the anus, and were also 10-15 cm long.

Both the stomach and intestine samples were carefully cleaned with sea water.

All samples except the bones were quick-frozen at a temperature of $-45^{\circ}C$, and the bone samples were frozen at $-15^{\circ}C$. The frozen samples were wrapped in oilpaper and put in zinc-lined boxes, which were then placed in larger wooden boxes. In order to improve the insulation of the samples, the free space between the walls of the boxes (approximately 10 cm) was filled with sawdust. Using such methods, samples were packed and stored at a temperature of $-10^{\circ}C$.

Immediately before investigation, the blubber, meat, and intestinal samples were defrosted and minced in a mincing machine. Before analysis the bone samples were cleaned of meat and sown into small pieces. The sawdust was analyzed*.

The chemical investigations of samples (meat, blubber, liver and skull bones) were partially carried out in the ship's laboratory during her voyage, and partially in VNIRO.

Moisture, total nitrogen, and ash content of the samples were determined by accepted methods**.

The different fractions of protein nitrogen were investigated using the Mindlina and Pal'min method; (except that the ammonia distillation was carried out by the micromethod) using the Shirokov- Pal'min apparatus /1/. The nonprotein nitrogen was determined in the water extract after precipitation of proteins by trichloroacetic acid.

The collagen content was determined using the method elaborated by the VNIIMP laboratory. This method is based on dissolving the collagen in the form of glutin by autoclaving it in weak acid (pH 5.6). In this case, the nonprotein nitrogenous substances were determined in the solution after precipitation of the proteins with tannin. The collagen nitrogen content was determined by calculating the difference between the total and nonprotein nitrogen in the solution.

In the calculation of the nitrogenous substances content of the samples we used the coefficient 5.55 for collagen and 6.25 for other proteins.

The Weight and Chemical Composition of the Finback Whale

The finback whale (Balaenoptera physalus L.) is the main industrial whale of the Antarctic. Its length varies from 17.4 to 25 m and is on the average 20.5 m. Its weight varies from 30 to 75 tons, and averages 50 tons.

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* [Ed. Note: Sawdust here means bone dust resulting from sawing].

** The Laboratory technician N. F. Ermolaeva helped with these analyses.

Lately, knowledge of the weight composition of finback whales has increased. Thus, Schubert /22/ reported the results of a number of weight determinations of whales found near Japan. Simultaneously with the total weight, the separate weights of the whole blubber, meat, bones, and intestines were also recorded.

In Ash's work /16/ an attempt was made to give an empirical and graphical definition of the total whale weight and the weight of its different body parts (blubber, meat, bones, and intestines) in relation to its length.

The results of our investigations on weight and chemical composition of separate parts and organs of the finback whale, carried out in 1952-1955, are given in Tables I, II, III, and IV.

Table I

Weight ratio of different body parts of finback whale

Body parts and organs	Male 20,1m long		Male 21,8m long		Female 18,5m long		Female 18,8m long		Female 22,0m long	
	Weight in Kg	% of total weight	Weight in Kg	% of total weight	Weight in Kg	% of total weight	Weight in Kg	% of total weight	Weight in Kg	% of total weight
Smooth subcutaneous blubber	5900	13.00	8217	13.40	6180	12.32	5391	11.90	7922	10.50
Abdomen (blubber in strips, with meat)	4400	9.70	7665	12.50	4400	8.77	5572	12.30	7771	10.30
Tongue	1600	3.52	1472	2.40	1150	2.29			2716	3.60
Lower jaw	1800	3.96	2514	4.10	1780	3.55	1495	3.30	3094	4.10
Head	2400	5.29	3618	5.90	3150	6.28	3216	7.10	5131	6.80
Vertebral column	3700	8.15	4660	7.60	4720	9.41	4213	9.3	8224	10.90
Caudal fin										
Ribs										
Rib meat	4100	9.03	4476	7.30	4130	8.23				
Pectoral fins					408	0.81	4258	9.40	7771	10.30
Shoulder blades	—	—	—		107	0.21				
Meat from under the vertebral column	7600	16.74	10179	16.60	7925	15.79	7112	15.7	12072	16.00
Meat from dorsal region	9100	20.04	13858	22.60	10850	21.62	9015	19.9	13883	18.40
Whalebone	500	1.10	552	0.90	730	1.45	589	1.3	981	1.30
Whole intestines including:	4300	9.47	4109	6.70	4650	9.27	4439	9.8	5885	7.80
Liver	600	1.32	368	0.60	540	1.08	906	2.0	981	1.30
Stomach	2100	4.63			250	0.50				
Intestines (bowels)					900	1.79				
Heart			3741	6.10	240	0.48	3533	7.80	4904	6.50
Lungs	1600	3.52			400	0.80				
Throat, pericardium, etc					2320	4.62				
	45400	100.0	61320	100.0	50180	100.0	45300	100.0	75450	100.0

According to our investigations, the oil content of the subcutaneous blubber of the finback whale varied from 66.3 to 80.5 % (Table II). The oil content of the layer of blubber at the base of the skull was a little less (average 69.0 %) than in the region of the dorsal fins (average 71.3 %). The oil content of the abdominal layer of blubber was 31.9 to 33.9 %.

Meat from the spinal and abdominal regions had approximately the same chemical composition (Table III). The oil content of the meat depended on the season, and, at the end of the fishing season (March), increased a little. Pregnant females were oilier, and nursing whales and males were leaner.

Table II

Chemical composition of the blubber and tongue of finback whale

Designation of test samples	Sex of whale	Length in m	Content in %		
			Moisture	Oil	Solid substances
Smooth subcutaneous blubber at level of dorsal fin	Male	21.0	21.86	71.94	6.20
	"	21.2	20.06	70.90	9.04
	"	21.2	20.92	69.68	9.40
	Female	21.2	18.50	71.20	10.30
	"	22.4	17.50	72.18	10.32
	"	20.4	16.85	68.90	14.25
	"	20.0	23.60	68.20	8.20
	Male	18.8	22.20	68.30	9.50
	"	18.7	14.20	80.50	5.30
	Female	18.2	21.30	71.00	7.70
Smooth subcutaneous blubber at base of skull	Male	21.2	20.19	68.60	11.21
	"	21.2	22.70	66.30	11.00
	Female	21.2	20.48	70.08	9.44
	"	22.4	20.65	70.90	8.45
Striped subcutaneous blubber (abdominal) along vertical line of pectoral fin	Male	21.2	47.88	32.18	19.94
	"	21.2	48.90	33.89	17.21
	"	21.2	49.80	31.90	18.30
	Female	21.2	46.70	33.40	19.90
	"	22.4	46.65	33.80	19.55
Tongue	Male	21.2	35.91	55.17	8.92

Heierdal* /21/ indicated that approximately 90 % of all the meat was lean, with an oil content of 3 to 6 %. Only in the caudal part of the spinal muscle did the oil content reach 20 %. The oil content increased from the anal region to the tail, and the oiliest meat could be found in the region of the ribs (15 to 25 %).

The chemical composition and the amino acid content of this meat was similar to that of cattle meat /11, 23/, but the whale meat contained more anserine and carnosine. This is connected with muscle work during diving. The whale meat also contained from 0.1 to 1 % mono, di- and tri-ethylamines, which made it similar to fish meat /23/.

The content of the B group vitamins in the whale meat /23/ was less (B_1 — 0.36 mg and B_2 — 2.50 mg in 1 g) than in cattle meat (in beef the pertinent values are 0.70 and 4.1 mg) and the amount of nicotinic acid was approximately the same as in beef (52 to 53 mg in 1 g).

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* [This name does not appear in the Russian bibliography /21/. Transl. note].

Table III

Chemical composition of meat of finback whale

Designation of test samples	Sex of whale	Length in m	Content in %			
			Moisture	Oil	Nitrogen substances	Ash
Meat from dorsal region						
head section	Female	23.1	70.30	7.52	21.25	1.01
" "	"	20.4	63.16	15.78	20.19	0.81
" "	"					
caudal "	"	21.2	74.38	3.65	21.97	
head "	"	21.2	57.54	21.21	21.25	
" "	Male	22.4	72.80	4.15	23.05	
caudal "	"	21.2	75.18	2.86	21.96	
head "	"	21.2	64.11	13.86	22.03	
" "	"	21.2	74.78	3.08	22.14	
Abdominal meat (at level of pectoral fins)		21.2	68.19	8.70	23.11	
	Female	21.2	72.12	5.00	22.88	
same	"	22.4	70.10	6.80	23.10	
"	Male	21.2	73.00	4.64	22.36	
"	"	21.2	71.12	5.96	22.92	
"	"	21.2	71.22	5.16	23.62	
"	Female	23.1	61.95	16.53	21.52	

The raw bones (Table IV) differed greatly in their composition, especially in oil content, the largest amount of oil being found in the caudal part of the vertebral column, (up to 45.4%). There was also a large amount of oil in the skull bones (up to 39.2%). The maxillary contained up to 47.6% of oil, but the oil content of the ribs and fins was considerably less (20 to 30%).

The oil content of the bones of the vertebral column depended on the marrow content /21/. Bones filled with red (blood) marrow (the upper part of the vertebral column, 25% of its total length) contained less oil (3.4 to 24%) than the bones of the lower part (38 to 67% oil), filled with yellow marrow.

In young whales only red marrow was found. But with aging, the red marrow changed to yellow, which contained a larger amount of oil.

The nitrogeneous substances content of the bones varied from 14.1% (the caudal part of the vertebral column) to 22% (ribs). The quantity of collagen in the different bones also varied. The largest quantity of collagen was found in ribs (average 45% of the total nitrogen quantity), and the smallest in the cerebral part of the vertebral column (approximately 18.5% of the total nitrogen content). Fins contained up to 30% of nitrogenous substances, the basic mass of which were collagens (63 to 87% of the total nitrogen content).

Of the internal organs, only the stomach contained a great deal of oil (73.9%), the intestines and liver being lean (4.9 to 12%).

The amount of nitrogenous substances in the stomach was not large (3.6%), whereas in the intestines they were present in large quantities (16%). The composition of the nitrogenous substances in the stomach and in the intestines differed: Thus collagen nitrogen averaged 24.6% in the small intestine, and 22.3% in the large intestine. In the stomach it was 12.07% of the total nitrogen.

The mineral substances content of the bones averaged 35% (30% in the

vertebral column and up to 39 % in the ribs); that of the fins and intestines was from 0.3 to 1 %.

Table IV

Chemical composition of bones, fins and intestines of the finback whale

Designation of test samples	Sex of whale	Length in m	Chemical composition in %				Composition of nitrogen substances in % from total nitrogen		
			Moisture	Oil	Nitrogen substances	Ash	Nitrogen of muscle proteins and of elastin	Nitrogen of collagen	Nonprotein nitrogen
Skull bones	Male	21,2	28,33	39,23	32,44		Not investigated		
" "	"	21,0	28,59	33,49	37,92		The same		
" "	"	20,0	39,49	27,26	33,23		"		
Jaw bones	"	21,0	12,90	35,90	51,20		"		
" "	"	20,3	12,00	37,40	50,60		"		
" "	"	21,2	15,23	40,43	44,34		"		
" "		20,0	15,43	47,64	36,93		"		
Bones of the vertebral column									
Head section	Male	20,0	12,89	37,35	20,44	30,24	79,34	18,86	1,80
Caudal section	"	20,0	15,04	33,35	18,37	32,47	31,33	62,66	6,01
Head section	Female	22,0	18,84	23,12	18,07	39,19	79,67	17,96	2,37
Caudal section	"	22,0	8,95	45,40	14,11	30,75	74,57	24,14	1,29
Bones of the vertebral column (average sample)	Male	21,0	13,18	34,00	52,82		Not investigated		
	"	20,3	12,80	35,60	51,60		"		
Ribs	"	20,0	15,64	24,95	20,52	37,56	69,62	28,32	2,06
"	Female	22,0	14,05	24,46	21,99	38,64	28,95	66,05	5,00
Shoulder blades	Male	21,2	30,23	32,66	37,11		Not investigated		
Fins									
Pectoral fin	"	20,0	48,15	19,77	31,42	0,49	35,87	63,21	0,92
Caudal "	"	20,0	49,96	18,92	29,33	0,30	11,93	87,11	0,95
Pectoral fin	"	21,2	29,63	35,99	34,38		Not investigated		
Caudal "	"	21,2	52,55	12,25	35,20		"		
Pectoral fin	"	22,0	52,67	16,39	29,61	0,58	26,75	73,25	—
Caudal "	Female	22,0	41,16	30,42	26,55	0,30	12,56	85,95	1,49
Whalebone	"	22,0	8,60	4,03	85,17	2,20	Not investigated		
"	Male	21,2	8,13	2,43	86,0	3,40	"		
Stomach	"	20,0	21,33	73,92	3,58	0,14	63,80	12,07	24,13
"	"	21,2	42,69	47,18	10,13		Not investigated		
Intestines									
Small intestine	"	20,0	78,54	4,92	15,49	0,95	60,78	25,49	13,73
" "	Female	22,0	70,68	11,38	16,91	0,90	68,35	23,74	7,91
Large intestine	"	22,0	70,14	12,11	17,27	0,71	59,51	24,29	16,20
" "	Male	20,0	76,49	7,22	14,97	0,80	65,73	20,40	13,87

Table V shows the average weight and chemical composition of separate body parts and organs of the finback whale, which were obtained from our data /8/.

Hence, the average weight of subcutaneous blubber was 16.8 % of the total whale weight. The smooth blubber was 11.8 %, and the abdominal blubber averaged 5 %. The weight of the head was 14 3 %, of which the tongue was 2.9 %, the lower jaw 3.5 %, the whalebone 1.2 %, and the brain, 0.01 %.

The total weight of bones, including the skull bones, was 23.0 %, and of the fins, 2 %.

The total meat, including abdominal meat, was 40 %, spinal meat, of the greatest value, was 21.2 %.

Table V

Average weight and chemical composition of body parts of the finback whale

Organs and body tissues	Average relative weight in kg according to data obtained from weighing 12 whales	Average chemical composition in %			
		Moisture	Oil	Nitrogen substances	Ash
Smooth subcutaneous blubber	11.8	17.73	74.91	7.19	0.15
Striped subcutaneous (abdominal)	5.0	48.50	31,14	19.65	0.50
Tongue	2.9	30.85	61,21	7.94	
Lower jaw bone	3.5	31.05	34,86	34.08	
Skull	6.7	37,30	33,78	28.91	
Brain	0.01	78.07	9,63	10.25	1.49
Bones of vertebral column	5	21.96	29,70	15.81	32.38
Ribs	4.0	24,79	19,02	18.09	38.10
Pectoral fins and shoulder blades	1.3	50.41	18,08	30.51	0.53
Caudal fin	0.9	47.51	20,95	30.33	0.31
Meat from dorsal region	21.2	69.67	6,37	22.95	1.01
Meat from underneath the vertebral column	15.0	62.29	16,10	20.60	1.0
Meat from ribs	4.5				
Meat from striped blubber	5.0	73.26	6,09	19.65	0.93
Liver	1.2	74.95	2.20	22.85	
Stomach	1.0	32.00	60.60	6.70	0.25
Intestines	1.7	73.96	8.90	16.16	0.84
Heart	0.5	76.81	2.06	22.73	1.07
Lungs	0.7	76.73	1.70	19.78	1 05
Throat, pericardium, kidneys, spleent, etc	3.2	78.75	2.53	18.72	
Whalebone	1.2	8.35	3.25	85.60	2.80
	99.80*	—	—	—	—

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* The 0.2 %, which is the amount missing to make up 100 %, refers (approximately) to the contents of the stomach and intestines, and to the loss of blood.

The intestines weighed 8.3 % of the total whale weight. The weight of the liver was 1.2 %.

The above-mentioned average weights of different whale-body parts are accepted as the norm in industrial processing of whales. It should be noted that the relative weight of different body parts of the whale may vary depending on sex, age, and the season when caught.

According to our observations, the possible fluctuations could be within the following limits:

The weight of smooth blubber, from 8.4 to 16.7 %; the weight of abdominal blubber together with the meat, 8.6 to 12.5 %; the weight of the head (without lower

jaw, tongue and whalebone), 5.3 to 8.1 %; the weight of the lower jaw, 2.3 to 4.1 %; the weight of the vertebral column with the caudal fin, 7.6 to 11.2 %; the meat weight (without abdominal and rib meat), 33.2 to 39.2 %, and the weight of the intestines, 6.7 to 10.8 %.

The weight and chemical composition of the sulphur-bottom whale

The sulphur-bottom whale (Balaenoptera musculus L.) is rarer in the Antarctic than the finback whale. It is the largest whale, and may reach 33 m in length and more than 150 ton in weight. The average length of the sulphur-bottom whale caught in the Antarctic is 23.6 m, and the weight, 83 ton. The female is usually bigger than the male. Data in literature concerning the weight and chemical composition of the sulphur-bottom whale are scarce. There are known results of the weighing of two sulphur-bottom whales caught in the region of South Georgia /19/, and of studies of the weight of 20 sulphur-bottom whales carried out by the Japanese /22/ (blubber, meat, bones, intestines), but the place of slaughter is not mentioned. Chemical investigations of body parts of a sulphur-bottom whale caught in Far Eastern waters (Kronetskii Bay) were made by Kaletina /5/. We do not have any other data concerning the chemical composition of this species of whale.

Table VI presents weight results obtained during our investigations on a sulphur-bottom whale caught in the Southern Ocean in comparison with the data from the two sulphur-bottom whales from South Georgia. The relative weights of the subcutaneous blubber, meat, head, and liver of the sulphur-bottom whale differed from those of the finback whale. The average weight of subcutaneous blubber in the sulphur-bottom whale was 16%, while in the finback whale it was 17 %.

The head weight of the sulphur-bottom whale was 13 %, of which the tongue was 2.3 % the lower jaw 2.8 %, and the whalebone 0.9 %. The weight of the bones and fins was 27 %.

The total output of meat was 46.3 %, of which the spinal meat was 20.1 %. The weight of the intestines was 8.1 %, and that of the liver, close to 0.9 %.

According to our investigations (Table VII) the average oil content of smooth oil subcutaneous blubber was approximately 73%, and of abdominal blubber, approximately 40 %.

Tables VIII and IX show our data on the chemical composition of sulphur-bottom-whale meat. The oil content of the spinal meat near the head and of the middle portion of the body was from 4.18 to 9.78 %, and of abdominal meat, 8 %.

According to Heierdal /21/, the oiliest meat in the sulphur-bottom whale was that of the dorsal side in the caudal region, with an oil content of 37%. The maximum oil content in that part of the body in the finback whale was 20 %. The tongue meat of the sulphur-bottom whale was a little oilier than that of the finback whale.

In composition of nitrogeneous substances (Table IX), the meat of the sulphur-bottom varied considerably from that of the finback whale. An average of 50% of the total nitrogeneous substances in the sulphur-bottom meat was that of the connective tissue proteins, of these, collagen was about 33%.

In comparison to finback-whale meat, that of the sulphur-bottom contained more vitamins of the B-group. B_1--0.48 mg and B_2-- 3.12 mg per gram /24/.

The chemical composition of the bones and fins is recorded in Table X. The oil content of the sulphur-bottom whale bones was a little higher than in the finback whale, but the head part of the vertebral column in the sulphur-bottom whale (the

same as in the finback whale), contained less fat (30 %) than the caudal part which contained 43 %. In nitrogen and mineral content, the bones of the sulphur-bottom whale were similar to those of the finback whale.

Table VI

Relative weight of body parts of the sulphur-bottom whale

Body parts and organs	Antarctic sulphur-bottom whale		Sulphur-bottom whales from the region of South Georgia			
	Female, 21,1 *m* long		20.3 *m* long		27.2 *m* long	
	In *meters*	% of total weight	In *meters*	% of total weight	In *meters*	% of total weight
Smooth subcutaneous blubber	7.75	11.18	9.12	18.7	25.65	21.0
Abdomen (striped blubber with meat)	6.50	9.39				
Tongue	1.30	1.88	1.10	2.3	3.16	2.6
Head	4.90	7.07	9.43	19.2	22.28	18.3
Lower jaw	1.92	2.77				
Vertebral column	7.00	10.70				
Caudal fin	0.35	0.50				
Ribs	3.15	4.55				
Pectoral fins	4.00	5.77				
Meat from back	13.93	20.10	25.94	53.0	56.44	46.3
Meat from underneath the vertebral column	11.80	17.03				
Whalebone	0.60	0.86	0.40	0.8	1.15	0.9
Whole intestines, including:	6.10	8.81	2.89	6.0	13.32	10.90
Liver	0.75	1.09	0.40	0.3	0.94	0.8
Stomach	0.30	0.43	0.20	0.4	0.41	0.3
Intestines	2.05	2.96	1.17	2.4	1.56	1.3
Throat and pericardium						
Heart	3.00	4.33	0.31	0.7	0.63	0.5
Lungs			0.59	1.2	1.23	1.1
Kidneys			0.22	0.5	0.55	0.4
Blood(approximately)	—	—	—	—	8.00	6.5
	69300	100.0	48.89	100.0	122.0	100.0

Tables XI and XII record the chemical composition of the intestines. In oil content, the intestines of the sulphur-bottom whale could be divided into 3 groups: 1) lean blubber with an oil content of 1 to 3% (heart and lungs), 2) medium-oily blubber with an oil content which averaged 12% of the intestinal oil, and 3) oily blubber with an oil content of up to 50% (stomach).

The various intestines also varied considerably in the content of nitrogenous substances (Table XII). The heart contained relatively less collagen (average, approximately 20 %), and the stomach and lungs considerably more (22 to 30 %).

Table XIII whows the average weight and chemical composition of the different

body parts of the sulphur-bottom whale and can be used for a general evaluation of its nutritional and industrial importance.

Table VII

Chemical composition of blubber of the sulphur-bottom whale

Designation of test samples	Sex of whale	Length of whale in meters	Content in %		
			Moisture	Oil	Solid substances
Smooth subcutaneous blubber at level of dorsal fin	Male	21.3	20.83	70.38	9.29
	"	21.5	13.08	78.06	8.86
	"	24.0	15.62	74.16	10.22
	Female	21.3	13.00	78.12	8.88
	"	24.8	12.62	78.60	8.78
	Male	24.0	18.40	71.80	9.80
	Female	26.2	31.20	57.00	11.80
Smooth subcutaneous blubber at base of the head	Male	21.9	17.25	70.00	12.75
	"	21.3	19.20	73.00	7.80
	"	25.6	15.30	78.90	5.80
	Male	21.5	16.90	76.12	6.98
	"	24.0	20.00	70.80	9.20
	Female	21.3	16.80	75.40	7.80
	"	24.8	17.60	74.20	8.20
Striped subcutaneous blubber (abdominal) at level of pectoral fins	Male	21.5	45.18	37.90	16.92
	"	24.0	41.80	40.66	17.54
	Female	21.3	42.08	40.20	17.72
	"	24.8	39.19	41.80	19.01

Table VIII

Chemical composition of meat of sulphur-bottom whale

Designation of test samples	Sex of whale	Length of whale in meters	Content in %			
			Moisture	Oil	Nitrogen substances	Ash
Meat from dorsal region at base of head	Male	23.0	70.25	7.48	21.13	0.93
at level of dorsal fin	"	23.0	62.92	9.78	24.84	1.20
same	Female	24.0	67.87	8.77	21.38	0.98
"	"	21.3	71.38	6.12	22.60	
"	"	24.8	70.15	8.20	21.65	
"	Male	21.5	72.65	5.16	22.19	
"	"	24.0	72.90	5.45	21.65	
"	"	23.0	74.37	4.16	19.75	0.97
"	"	23.9	72.50	4.18	22.25	1.32
Abdominal meat at level of pectoral fins	Female	24.0	66.47	7.71	24.75	0.94
same	"	21.3	69.90	8.02	22.08	
"	"	24.8	68.40	8.77	22.83	
"	"	21.5	71.18	8.00	20.82	
"	"	24.0	70.00	8.00	22.00	
Tongue	"	23.0	63.46	21.11	14.31	0.54

Table IX

Composition of nitrogeneous substances in meat of sulphur-bottom whale

Designation of test samples	% of total nitrogen							
	Nitrogen of water-soluble proteins	Nitrogen of salt-soluble proteins	Nitrogen of alkali soluble proteins	Collagen nitrogen	Elastin nitrogen	Total nitrogen of muscle proteins	Total nitrogen of connective tissue	Nonprotein nitrogen
Meat from back at base of head	4.44	12.43	15.08	35.21	16.27	31.95	51.48	16.29
Back meat at level of dorsal fin	3.27	7.81	28.71	29.22	11.84	39.79	41.06	17.88
same	3.80	7.60	21.64	36.25	19.01	33.04	55.26	11.11
Abdominal meat at level of pectoral fins	4.54	11.36	35.60	22.97	10.81	51.52	33.79	14.90
Tongue meat	13.97	5.68	21.21	34.06	19.65	40.86	53.71	5.06

Table X

Chemical composition of bones and fins of the sulphur-bottom whales

Designation of test samples	Sex of whale	Length of whale in m	Chemical composition in %				Composition of nitrogen substances in % from total nitrogen		
			Moisture	Oil	Nitrogen substances	Ash	Nitrogen of muscle proteins and elastin	Collagen nitrogen	Nonprotein nitrogen
Vertebral bones									
Head section	Male	22.3	12.49	29.08	27.94	30.08	64.23	32.54	3.23
Caudal section	"	22.3	11.82	41.15	18.55	28.97	32.81	64.69	2.50
Head section	Female	21.3	21.81	31.67	22.91	24.29	83.83	11.05	5.12
Caudal section	"	21.3	13.75	44.76	16.93	24.86	77.61	19.86	2.53
Bones of the vertebral column (average)	"	24.0	12.10	37.50	50.50		Not investigated		
same	"	24.8	11.98	38.40	49.62		Same		
"	Male	21.5	12.83	37.30	49.82		"		
"	"	24.0	12.05	37.30	50.65		"		
Ribs	"	22.3	18.84	16.78	23,14	40.62	36.20	55.95	7.85
"	Female	21.3	17.97	33.44	18.33	30.16	64.57	25.83	9.60
Jaw bones	"	21.3	11.60	39.30	49,10		Not investigated		
" "	"	24.0	11.80	40.60	47,60		Same		
" "	Male	21.5	12.06	39.30	48,64		"		
" "	"	24.0	11.82	39.30	48,88		"		
Pectoral fins	Male	22.3	32.48	52.40	14.62	0.14	5.75	93.10	1.15
Caudal fins	"	22.3	51.38	18.42	29.25	0.23	7.15	86.29	6.56
Pectoral fins	Female	21.3	66.20	3.78	29.81	0.16	42.12	54.53	3.35
Caudal fins	"	21.3	47.04	21.88	30.02	0.32	15.67	83.77	0.56

Table XI

Chemical composition of the intestines of sulphur-bottom whale

Designation of test samples	Sex of whale	Length of whale in meters	Content in %			
			Moisture	Oil	Nitrogeneous substances	Ash
Heart	Male	23.0	78.65	1.60	18.44	1.03
"	Female	24.0	76.89	1.89	19.38	1.09
Lungs	"	24.0	73.75	2.34	21.88	0.93
"	Male	23.0	69.93	1.12	27.56	1.01
Stomach	"	22.3	41.51	47.67	10.33	0.32
"	Female	21.3	38.28	52.55	7.94	0.35
Intestines (small)	"	21.3	78.75	5.34	14.34	1.02
" "	Male	22.3	62.11	20.04	17.18	0.71
" (large)	"	22.3	68.20	16.26	14.60	0.89
" "	Female	21.3	75.65	5.84	16.41	1.20

Table XII

Composition of nitrogeneous substances of the intestines of sulphur-bottom whale

Designation of test samples	In % of total nitrogen								
	Nitrogen of water-soluble proteins	Nitrogen of salt-soluble proteins	Nitrogen of alkali-soluble proteins	Collagen nitrogen	Elastin nitrogen	Total nitrogen of muscle proteins	Total nitrogen of muscle protein and elastin	Total nitrogen of connecting tissue proteins	Nonprotein nitrogen
Heart	23.39	14.59	32.88	13.22	3.05	70.85	—	16.27	12.54
"	9.03	10.97	36.77	27.10	0.31	56.77	—	27.41	16.12
Lungs	13.14	10.57	15.14	21.71	27.42	38.86	—	52.13	8.86
"	8.62	7.71	12.07	36.96	29.47	28.40	—	66.44	5.22
Stomach	Not investigated			24.71	—— Not investigated ——	-	65.88	—	9.41
"				17.81		—	70.17	—	11.72
Intestines (small)	"			17.52		—	62.39	-	20.09
Intestines (small)	"			25.80		—	57.95	—	16.25
Intestines (large)	"			20.08		—	63.60	-	16.32
Intestines (large)	"			21.19		—	62.45	—	16.36

Table XIII

Average weight and chemical composition of body parts of the sulphur-bottom whale

Organs and body tissues	Average relative weight in %	Average chemical composition in %			
		Moisture	Oil	Nitrogen substances	Ash
Smooth subcutaneous blubber	11.2	19.31	72.80	7.88	
Abdominal subcutaneous blubber (striped)	4.7	47.75	32.82	19.42	
Tongue	2.3	34.10	56.39	8.94	0.57
Lower jaw	2.8	11.82	39.57	48.60	
Head	7.0	33.10	33.79	11.79	21.14
Brain	0.006	78.45	9.20	10.46	1.41
Vertebral bones	10.7	13.87	39.81	19.66	26.48
Ribs	4.6	19.40	25.11	20.73	35.39
Pectoral fins and shoulder blades	1.3	49.34	28.09	22.21	0.15
Caudal fin	0.6	49.21	20.15	29.63	0.27
Meat from dorsal region	20.1				
Meat from underneath vertebral column	17.0	69.50	6.92	22.00	1.01
Meat from ribs	4.5				
Meat from striped blubber	4.7	66.47	7.71	24.75	0.94
Liver	0.9	74.90	2.95	22.15	
Stomach	0.4	39.89	50.11	9.13	0.33
Intestines	1.2	71.17	11.87	15.63	0.95
Heart	0.6	77.77	1.74	18.91	1.06
Lungs	1.1	71.84	1.73	24.72	0.97
Throat, pericardium, kidneys, etc	3.0	78.75	2.53	18.72	
Whalebone	0.9	8.60	4.03	85.17	2.20
	99.60*	—	—	—	—

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* The 4 % which is the amount missing to make up 100 % refers approximately to the contents of the stomach and intestines and to the loss of blood.

The Weight and Chemical Composition of the Humpback Whale

Humpback whales (Megaptera nodosa Bon.) are the smallest of the whales of industrial importance of the Antarctic. The length of the humpback whale varies from 11 to 16 m, averaging approximately 12.7 m, and the weight varies from 19 to 50 tons, 26 tons on the average.

In the relevant literature very few data can be found on the weight of the humpback whale. The most complete data were obtained by Zenkovich upon weighing of two Far Eastern humpbacks /3/. In Ash's work /17/ an attempt was made to establish the total weight of the Antarctic humpback whale according to an empirical formula using the quantity of whales caught, their length, and output obtained.

The most complete data on the weights of separate body parts and organs of the humpback whale were obtained by the scientific group on the whaler "Slava" (Tables XIV and XV).

According to our observations the total weight of the humpback whale increased considerably with a small increase in body length. Thus, a female 13.9 m long, weighed approximately 40.77 tons, and one of 14.0 m weighed 43 tons.

Table XIV

Chemical composition of separate body parts of the humpback whale

Body parts and organs	Male 11.8 m long		Male 14.0 m long		Female 12.6 m long		Female 13.5 m long		Female 13.9 m long		Female 14.0 m long		Female 15.0 m long	
	Weight in Kgs	% of total weight	Weight in Kgs	% of total weight	Weight in Kgs	% of total weight	Weight in Kgs	% of total weight	Weight in Kgs	% of total weight	Weight in Kgs	% of total weight	Weight in Kgs	% of total weight
Smooth subcutaneous blubber	3155	14.25	5175	11.18	3200	12.17	4190	12.08	4850	11.93	5897	13.48	8900	16.85
Abdomen (striped blubber with meat)	3650	16.48	5675	12.26	3700	14.07	5525	15.93	5150	12.66	4540	10.38	6600	12.50
Tongue			1665	3.60					1369	3.34	1080	2.47		
Head	1650	7.45	3225	6.97	1750	6.65	2600	7.50	3750	9.22	2883	6.59	3215	6.11
Lower jaw	820	3.70	1765	3.81	1050	3.99	1310	3.78	2025	4.98	1330	3.04	1865	3.53
Vertebral column	1675	7.56	3300	7.13	1900	7.23	2480	7.15	3500	8.61	3150	7.20	3925	7.43
Caudal fin	400	1.81												
Ribs	920	4.15	8850	19.12	4500	17.11	6990	20.16	2125	5.23	2480	5.67	10590	20.05
Pectoral fins	500	2.26							1200	2.95	6090	13.92		
Shoulder blades	100	0.45							270	0.66				
Meat from ribs	2750	12.42							2725	6.70				
Meat from dorsal region	2500	11.29	7100	15.34	3950	15.02	4440	12.81	4720	11.61	6500	14.86	6700	12.69
Meat from underneath the vertebral column	2250	10.16	5950	12.86	3750	14.26	3930	11.33	3925	9.65	5850	13.38	6875	13.02
Whalebone	Not accounted for		350	0.76	300	1.14	350	1.01	675	1.66	310	0.71	400	0.76
Whole intestines	1775	8.02	3230	6.97	2000	8.36	2860	8.25	4394	10.80	3630	8.30	3730	7.06
including:														
Liver	350	1.58	1340	2.89	1200	4.56	1440	4.15	669	1.64			1690	3.20
Stomach	800	3.62							300	0.74				
Intestines	125	0.56							1675	4.12				
Heart	150	0.68	1890	4.08	1000	3.80	1420	4.10					2040	3.86
Lungs														
Throat, pericardium and other internal organs	350	1.58							1750	4.30				
	22145	100.00	46285	100.00	26300	100.00	34675	100.00	40669	100.00	43740	100.00	52810	100.00

Table XV

Relation between size of humpback whales and weight of their body parts

Length of the whale in meters	Total weight in kg	In % of total weight				
		Meat	Blubber, abdomen, and tongue	Bones	Intestines	Whalebone
Males						
11.8	22145	33.87	30.73	27.38	8.02	Not accounted for
14.0	46285	28.20	27.04	37.03	6.97	0,76
Females						
12.6	26300	29.28	26.24	34.98	8.36	1.14
13.5	34675	24.14	28.01	38.59	8.25	1.01
13.9	40669	27.96	27.93	31.65	10.80*	1.66
14.0	43740	28.24	26.33	36.42	8.30	0.71
15.0	52810	25.71	29.35	37.12	7.06	0.76

* Weight of intestines together with fetus

Table XVI

Chemical composition of separate body parts and organs of the humpback whale

Designation of test samples	Chemical composition in %				Composition of nitrogen substances in % of total nitrogen		
	Moisture	Oil	Nitrogen Substances	Ash	Nitrogen of muscle protein and elastin	Elastin nitrogen	Nonprotein nitrogen
Meat from back at base of pectoral fins	67.50	11.62	16.63	0.99	78.15	12.96	8.89
Meat at level of dorsal fin	68.73	12.66	17.89	0.85	75.26	14.43	10.31
Tongue	36.15	56.70	6.60	0.58	85.98	12.15	1.87
Vertebral column							
Head section	17.53	15.98	26.62	39.60	63.43	34.54	2.03
Caudal section	10.87	41.15	17.64	31.12	60.00	38.64	1.36
Ribs	13.34	12.61	24.73	48.81	36.55	59.91	3.54
Pectoral fins	37.85	35.78	24.46	0.64	39.48	56.93	3.59
Caudal fins	49.30	21.81	27.75	0.36	12.73	78.85	8.42
Heart	63.98	23.75	11.05	0.71	74.03	21.55	4.42
Lungs	79,86	2.46	15.08	1.45	70.44	20.65	8.91
Stomach	31.91	61.01	6.47	0.17	67.92	21.70	10.38
Intestines (small)	64.13	21.79	12.96	0.60	68.25	15.64	16.11
Intestines (large)	68.77	17.11	13.38	0.84	66.51	16.52	16.97

The weight of subcutaneous blubber in the humpback whale was from 11.2 to 16.8 % (average 13.1 %) of the total weight, and the abdominal blubber varied from 10.4 to 15.9 %. The weight of the head, without the lower jaw and tongue, was from

6.1 to 9.2 % (average 7.2 %). The weight of the vertebral column, with the caudal fin, was from 7.1 to 9.4 % (average 7.7 %).

The weight of the meat, not including abdominal meat, averaged 35 %, and that of the intestines, 8.25 % (fluctuations from 7.0 to 10.8 %); of these the liver was approximately 1.5 %. Thus, according to Table XV, the relative weight of blubber, abdomen, and tongue in the humpback whale was constant and did not depend on the size and total weight of the animal; but the relative weight of the intestines decreased proportionally to the increase in the size of the whale.

We could not find data in the relevant literature concerning the chemical composition of the body parts and organs of the humpback whale.

Table XVII

Average weight and chemical compostion of various body parts of the humpback whale

Organs and body tissues	Average in %				
	Average relative weight in % according to data from 7 weighings	Moisture	Oil	Nitrogen substances	Ash
Smooth subcutaneous blubber	13.1	24.73	66.37	8.76	
Striped subcutaneous blubber (abdominal)	5.9	42.56	40.30	17.14	
Tongue	3.1	34.15	57.40	8.45	
Head	7.2	17.16	30.64	15.39	36.56
Lower jaw	3.9	20.90	41.85	13.48	24.64
Brain	0.01	77.45	10.55	10.06	1.59
Bones of the vertebral column	6.5	13.21	32.34	20.79	34.09
Ribs	5.0	13.31	12.61	24.73	48.81
Pectoral fins and shoulder blades	3.2	37.85	35.78	24.46	0.64
Dorsal fins	1.3	49.30	21.81	27.75	0.36
Meat from dorsal region	13.4	67.77	10.06	20.31	1.01
Meat from underneath vertebral column	12.1				
Meat from ribs	9.6	62.94	17.96	18.05	1.12
Meat from striped blubber	5.9	72.95	5.47	20.07	1.21
Liver	1.6	75.60	2.70	21.70	
Stomach	0.8	31.91	61.01	6.47	0.17
Intestines	1.3	66.45	19.45	13.17	0.72
Heart	0.6	73.98	13.75	11.05	0.71
Lungs	0.9	79.86	2.45	15.08	1.45
Throat, pericardium, spleen etc	3.0	78.75	2.53	18.72	
Whalebone	1.0	8.60	4.03	85.17	2.20
	99.40*				

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* The 0.6 %, which is the amount missing to make up 100 %, refers approximately to the contents of the stomach and intestines, and to the loss of blood.

Khar'kov /15/ established the general chemical composition of separate body parts, and also the physicochemical characteristics of oil from the Far Western humpback whale.

We examined the meat, bones, fins, and intestines of a female Antartic humpback whale 14.0 m long. Results of this analysis are recorded in Table XVI. According to these the meat, heart, intenstines, caudal fin, ribs, and the cerebral part of the vertebral column of the whale contained 12.6 to 23.7 % oil, which means that they constituted raw material of medium oiliness. More oil was found in the stomach, the tongue meat, the caudal part of the vertebral column, and the caudal fin, which had an oil content from 35.8 to 61%. It should be noted that the intestines and fins of the humpback whale contained more oil than the same organs in the finback and sulphur-bottom whales.

The nitrogenous substances content of the different body parts and organs of the humpback whale can be divided into 3 groups. 1) High nitrogenous substances content, 24.5 to 27.8 %, — fins, ribs, and cerebral part of the vertebral column ; 2) Medium nitrogenous substances content, 11.1 to 17.9 %, — spinal meat, lungs, heart, intestines, and caudal part of the vertebral column; and 3) Low nitrogenous substances content (up to 6.6 %) — the stomach and tongue.

The meat and heart had the highest protein nitrogen content (without collagen), (74 to 85% of the total nitrogen), the remaining viscera and the bones of the vertebral column came next (60 to 70 % of the total nitrogen content). The ribs and fins contained the least protein nitrogen, 12.7 to 39.5 % of the total nitrogen content. The lowest collagen content was found in the meat and intestines (12.1 to 14.4 % of the total nitrogen content), and the highest, in the ribs and fins (56.9 to 78.8% of the total nitrogen content). Heart, lungs, stomach, and vertebral column had a medium amount (20.6 to 38.6 % of the total nitrogen content).

Meat, fins, and intestines contained an average of approximately 0.7 % mineral substances; the stomach contained 0.17 %, the lungs 1.45 %, the bones of the vertebral column approximately 35 % , and the ribs 43 %.

Table XVII records the average weight and chemical composition of separate body parts of the humpback whale.

The Weight and Chemical Composition of the Sperm Whale

The sperm whale (Physeter catodon L.) is the only toothed whale of industrial importance in the Antarctic, and in the whaling areas only adult male specimens can be found. The female and young sperm whale frequent warmer seas. The size of the male sperm whale varies from 13 to 17 m (average 14.5 m) and the average weight is 30 tons.

We have not found any data in the relevant literature on the weight of sperm subcutaneous blubber in the sperm whale was a little larger (23.2%) than in the finback whale (21.8%), and in the sulphur-bottom whale (20.6%), but smaller than in the humpback whale (24.9%).

Table XVIII records results of weighing sperm whales on board the whaler "Slava" in comparison to the weights of sperm whales caught in Far Eastern waters. The relative weight of body parts and bones in the sperm whale is different, e.g., the weight of the head of the sperm whale together with spermaceti sac and lower jaw, was 37 % of the total body weight, while in whalebone whales Mystacoceti, the weight of the head with the tongue, lower jaw, and whalebone fluctuated from 12.6 % in the sulphur-bottom to 15.2 % in the humpback whale. The relative weight of integumentary blubber in the sperm whale was a little larger (23.2 %) than in the finback whale (21.8 %), and in the sulphur-bottom whale (20.6 %), but smaller than in the humpback whale (24.9 %).

Table XVIII

Weight relation between body parts of the sperm whale

Body parts and organs	Antarctic sperm whale (Male 16.1m long)		Far East sperm whale			
			Length 13.45 m		Length 18.0 m	
	Weight in Kgs	% of total weight	Weight in Kgs	% of total weight	Weight in Kgs	% of total weight
Subcutaneous blubber	11450	24.06	4955	21.86	12662.5	23.73
Sperm sac	8665	18.20	620	2,73	5757	10.79
Soft tissues of the head	4400	9.24	3981	17.56	10343	19.38
Cranium with upper jaw	4100	8.61	1800	7.94	6087	11.41
Lower jaw	1050	2.21	320	1.41	880	1.65
Vertebral columns	3455	7.26	1985.5	8.76	3387	6.35
Caudal fin			314	1.38	715	1.34
Ribs	3290	6.91	965	4.26	2147	4.02
Pectoral fins and shoulder blades			485	2.14	978	1.83
Chest bone			209	0.92	329	0.62
Pelvic bones			108	0.48	200	0.37
Meat from underneath the vertebrae column	3900	8.19	5640	24.88	7679.5	14.39
Meat from dorsal region	3950	8.30				
Whole intestines including:	3340	7.02	1282	5.66	2199.5	4.12
Liver	620	1.31	331*	1.46	368*	0.69
Stomach						
Intestines	700	1.47	254	1.12	465	0.87
Heart			113	0.50	211	0.40
Lungs			161.5	0.71	317	0.59
Throat, percardium, esophagus, etc.	1300	2.73				
Other Intestines	720	1.51	422.5	1.87	838.5	1.57
	476000	100.00	22664.5	100.00	53364.5	100.00

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* Liver together with kidneys

The amount of meat in the sperm whales was considerably smaller (approximately 19.0 %) than in the whalebone whales (from 35.1 % in the humpback whale to 41.6 % in the sulphur-bottom whale).

The relative weight of the total bones (without skull bones), approximately 16 %, was almost the same in all species of whales. The weight of intestines in the sperm whale was approximately 6.0 %, and in whalebone whales 7.5 to 8.5 %.

In the relevant literature, little information concerning the chemical composition of the sperm whale has been found. Some data on the meat of the Far Eastern sperm whale was published by Petersen /20/, and in Khar'kov's work /15/ there are data on the chemical composition of separate body parts and organs of the Far Eastern sperm whale.

Table XIX records data of an experiment on the chemical composition of the sperm whale, which was made on a male 16.1 m long, caught in the Antarctic.

Table XIX

Chemical composition of some body parts and organs of the sperm whale

Designation of test samples	Chemical composition in %				Composition of nitrogen substances in % of total nitrogen		
	Moisture	Oil-wax	Nitrogen substances	Ash	Nitrogen of muscle proteins and elastin	Collagen nitrogen	Nonprotein nitrogen
Meat from dorsal region at base of pectoral fin	75.15	2.87	20.55	0.93	71.51	21.66	6.83
Meat at level of dorsal fins	75.65	2.48	19.44	0.91	63.25	28.03	8.72
Meat of abdominal section	50.64	35.68	12.69	0.61	86.41	13.10	0.49
Tongue	74.96	2.16	22.08	0.99	66.85	28.49	4.66
Vertebral column (caudal part)	12.47	52.56	9.44	24.83	56.97	39.87	3.16
Lungs	79.45	2.81	16.80	0.70	89.30	7.75	2.95
Stomach	75.37	1.07	22.94	0.57	41.78	37.07	21.15
Intestine (small)	71.12	12.72	15.07	0.89	32.68	45.27	22.05

Table XX

Average weight and chemical composition of separate body parts of the sperm whale

Organs and body parts	Average chemical composition in %				
	Average relative weight in %	Moisture	Oil-wax	Nitrogen substances	Ash
Subcutaneous blubber	23.2	34.0	50.90	15.03	
Spermacetic "	10.6	1.98	97.28	0.73	
Soft head tissues	15.4	48.44	25.88	25.53	
Cranicum with upper jaw	9.3	19.96	43.11	12.54	24.41
Lower jaw	1.7				
Bones of vertebral column	7.5	20.38	39.45	15.17	24.93
Ribs	4.9	19.36	26.20	20.00	34.47
Pectoral fins and shoulder blades	2.0	60.71	8.22	30.32	0.64
Caudal fin	1.4	50.57	21.18	27.26	0.68
Meat from dorsal region	9.5	72.90	3.11	22.46	1.00
Meat from underneath the vertebral column	9.1	74.17	1.93	22.63	1.07
Liver	1.2	74.90	2.20	22.9	
Stomach	0.8	75.37	1.07	22.94	0.57
Intestines	1.0	71.12	12.72	15.07	0.89
Heart	0.45	78.42	7.11	14.47	
Lungs	0.65	79.45	2.81	16.80	0.70
Throat, pericardium, Kidneys, spleen etc.	1.0	78.75	2.53	18.72	
	99.70*				

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* The 0.3 %, the amount missing to make up 100 %, refers approximately to the contents of the stomach and intestines and to the loss of blood.

Our data on the chemical composition of the different body parts of an Antarctic sperm whale resemble the facts obtained about Far Eastern sperm whales by Petersen and Khar'kov.

Unlike the whalebone whales, the stomach and tongue of the sperm whale contained less oil, and therefore had no value as raw material for blubber rendering.

All the body parts of the sperm whale examined had a higher collagen content than the corresponding body parts and organs in the whalebone whales.

The average weight and chemical composition of the separate sperm whale body parts, calculated on the basis of data obtained, are given in Table XX.

According to these data the chemical composition of the blubber, meat, bones, and intestines, as a percentage of the total weight of the whale, was calculated. This enabled us to determine the average chemical composition of the whole whale. These data are given in Table XXI.

Table XXI

Chemical composition (in %) of separate body parts of the whalebone whale [Mystcoceti] and of the sperm whale

Designation of body parts	Whalebone whale				Sperm whale			
	Moisture	Oil	Nitrogen substances	Mineral substances	Moisture	Oil	Nitrogen substances	Mineral substances
Subcutaneous blubber (smooth and striped)	5.80	12.01	2.09	0.10	7.89	11.82	3.20	0.29
Spermacetic blubber	—	—	—	—	0.21	10.31	0.07	0.01
Soft head tissues of the sperm whale	—	—	—	—	7.49	3.98	3.60	0.33
Bones	5.05	7.52	3.88	7.02	4.68	8.97	3.50	6.25
Meat	30.14	4.23	9.51	0.45	13.68	0.48	4.19	0.25
Intestines	5.65	0.82	1.34	0.09	3.87	0.25	0.90	0.08
Fins	1.29	0.78	0.78	0.01	1.92	0.46	1.00	0.02
Whalebone	0.09	0.04	0.89	0.02	—	—	—	—
Moisture losses (blood, contents of stomach, intestines etc)	0.43	—	—	—	0.30	—	—	—
	48.44	25.39	18.48	7.69	40.04	36.27	16.46	7.23

Thus, according to Table XXI, the amount of basic nutritious substances (oil and protein) in whalebone whales averaged 44 % and in sperm whale, 53 %. The oil content of the sperm whale was 36 %, whereas it was 24 % in the sulphur-bottom and 27 % in the humpback whale. On the average it was 35 % of the body weight of the whalebone whale.

The quantity of nitrogenous substances in whalebone whales varied from 17.7 % (humpback) to 19.4 % (sulphur-bottom), and in the sperm whale it was 16.5 %. The mineral substances content was approximately the same.

The preparation of whales on board the whaler "Slava" was limited to four kinds of products: 1) Oil, rendered from the subcutaneous blubber, abdomen, bones, tongue, meat, and intestines, 2) Edible meat from the meat and protein remaining after the rendering of the blubber, 3) Salted liver as a semi-manufactured product containing Vitamin A, and 4) Semi-manufactured products for the preparation of campolon* (from fresh liver).

The intestines and the whalebone were not utilized, but were treated as offal.

Our investigation indicated that not all the types of raw material utilized for the rendering of blubber were suitable for this purpose because of their low oil content. It is well known that when lean is rendered together with oily raw material, the output of oil considerably decreases because of the absorption of oil by the leaner raw material. In these cases thick oil presscakes are formed which need special apparatus for oil extraction.

The accepted methods for the preparation of the raw whale material were limited by the technical equipment available, and by the lack of space for new equipment. But in the building of new whaling ships, space should be provided for more efficient utilization of the whales. In the papers (2/4/7/12/13/14/) prepared by VNIRO, the necessity of technological changes in whale processing has been mentioned.

1. It is advisable to extract the subcutaneous blubber by the cold method, i.e., by pressure. The upper layer of subcutaneous blubber of the sperm whale should be utilized for leather preparation after pressing. The remainder of the pressed proteins of whalebone whale blubber and the lower layer of sperm whale blubber should be used for gelatin and glue preparation.

The fins should also be used for these purposes.

2. The dorsal meat, heart, and kidneys of whalebone whales should be used for food, i.e., for preserves and dry protein preparations.

3. Meat meal should be made from lean raw material unfit for food, e.g., meat of lungs and neck. For preparation of meat and bone meal the presscakes, left over from the rendering of the blubber, should be used.

4. The endocrine glands and brain should be used for the preparation of medical and technical products (insulin, cortin etc).

5. The liver should be prepared in a complex manner, in order to obtain three products simultaneously: campolon, concentrated vitamin A, and protein fodder in the form of liver meal, containing vitamins of the B group.

6. The spermacetic oil of the sperm whale should be specially prepared for use in the cosmetic industry.

7. The whalebone and teeth should be used as raw material for sculpture or for false teeth.

Figures 1 and 2 demonstrate schemes for the rational utilization of whalebone and toothed whales.

Practical uses of raw whale are shown in Table XXII. According to

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* See editor's note on page 1 of this article.

this table, the oil content in the humpback whale is 6.5 tons and in the sulphur-bottom whale, 18.7 tons. Correspondingly the output of raw material for gelatin preparation may vary from 1.90 tons (humpback) to 4.30 tons (sperm whale).

The quantity of meat which can be utilized for food purposes, is from 3.6 tons (humpback) to 17.2 tons (sulphur-bottom).

From each sperm whale up to 2.9 tons of meat can be used for dry protein preparation. In addition, from each whale, 11.4 tons (sperm whale) to 40 tons (sulphur-bottom whale) of raw material can be used for the preparation of bone meal.

The potential output of different products by complex utilization of the liver of one whale is demonstrated in Table XXIII.

Table XXII

Average yield of raw material from various kinds of whales*

Designation of raw material according to processing methods	Finback whale: Average length 20.4 m, Average weight 50 Tons		Sulphur-bottom whale: Average length 23.6 m, Average weight 83 Tons		Hump-back whale: Average length 12.7 m, Average weight 26 Tons		Sperm whale: Average length 14.6 m, Average weight 30 Tons	
	% of the whale's wt.	Tons	% of the whale's wt.	Tons	% of the whale's wt.	Tons	% of the whale's wt.	Tons
Raw material for obtaining oil								
Edible	23.6	11.80	22.5	18.70	25.0	6.50	—	—
Commercial	—	—	—	—	—	—	24.9	7.5
Spermacetic	—	—	—	—	—	—	10.6	3.20
Non-oily blubber and fins for gelatin production	4.8	2.4	4.5	3.70	7.5	1.90	14.3	4.30
Meat for edible purposes (preserves, culinary preparations, dry protein)	21.7	10.85	20.7	17.2	14.0	3.60	9.5	2.90
Non-oily bones, meat, and intestines for preparation of meat bone meal	46.3	23.15	49.1	40.75	49.0	12.70	38.1	11.40
Liver, for preparation of complex compolon, Vitamin A, and liver meal for fodder	1.1	0.55	0.9	0.75	1.6	0.40	1.2	0.40
Raw endocrine glands for the manufacture of medical preparations	0.1	0.55	0.1	0.08	0.1	0.03	0.1	0.03
Whale bone for the orthopedic-braces industry	1.1	0.55	0.9	0.75	1.0	0.26	—	—
Intestines (waste)	1.2	0.60	1.2	1.00	1.3	0.34	1.0	0.30
		49.95		82.93		25.73		30.03

* In various periods of whaling, depending on the physical condition of the whales, their size and their sex, the yield of different kinds of raw material is subject to considerable fluctuations.

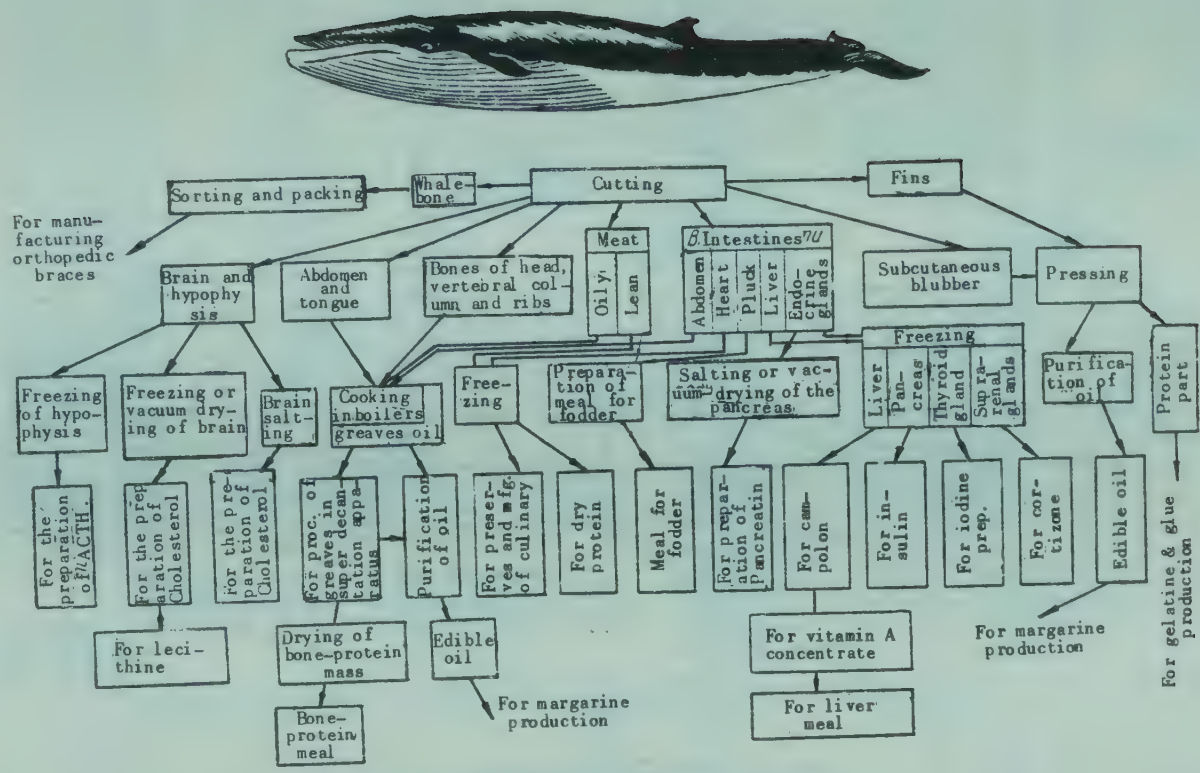

FIGURE 1. Scheme for efficient exploitation of whalebone whales

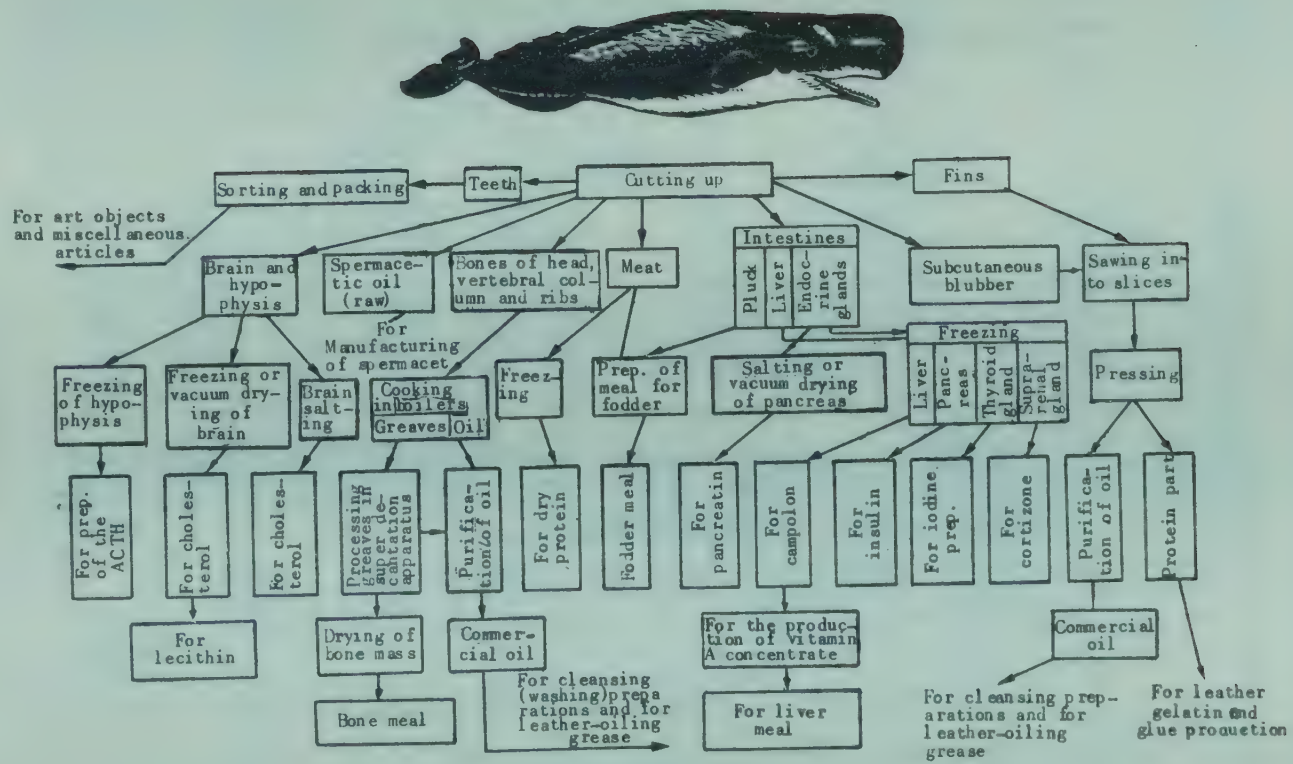

FIGURE 2. Scheme for efficient exploitation of the sperm whale

Table XXIII

Designation of products	Finback whale	Sulphur-bottom whale	Hump-back whale	Sperm whale
	Weight of the liver in Kgs			
	550	750	400	400
Campolon (in kgs)	27.5	37.5	20.0	20.0
Liver meal (in kgs)	140.0	190.0	100.0	100
Vitamin A (in millions of international units)	500	2300	176	1850

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* The average yield of vitamin A is calculated at 80 % of its content in raw liver.

Concerning the question of utilization of the intestines, investigation of their vitamin B, and especially vitamin B_{12}, content, should be undertaken. If the vitamin content proves to be sufficient, the intestines should be utilized for the production of cattle foddrr.

CONCLUSIONS

Investigations on Antarctic whales (finback, sulphur-bottom, humpback and sperm whales) enabled us to establish the following average output of different body parts during preparation of the whole whale under industrial conditions (in % of the total whale weight).

	Whalebone whales	Sperm whales
Meat	44	18.6
Bones and fins	27	27
Subcutaneous blubber and tongue	20	49 (including soft tissue of head)
The whole intestines,	8.0	5.5
including the liver	1.2	1.2
The whalebone	1.0	—

The relative weights of body parts in different types of whalebone whales are not the same. In the bigger sulphur-bottom whale the output (in percentage) of subcutaneous blubber and tongue, lower jaw, and fins is less, and that of the vertebral column and meat more than in the finback whale and humpback whale, which are the smallest in the whalebone group.

	Sulphur-bottom	Finback	Humpback
Subcutaneous blubber	15.9	16.8	19.0
Tongue	2.3	2.9	3.1
Lower jaw	2.8	3.5	3.9
Fins	1.9	2.2	4.5
Vertebral column	10.7	8.5	6.5
Meat	46.3	45.7	41.0

The relative weights of intestines and bones in all types of whalebone whales are approximately the same. The chemical composition of different body parts and organs vary, depending on the type, sex, and physiological state of animal, but the average chemical composition (in percentage) of whalebones, as calculated per body weight, is approximately the same even though differing considerably from the chemical composition of the sperm whale.

	Whalebone Whale	Sperm Whale
Oil	25.4	36.3
Nitrogenous substances	18.5	16.5
Mineral substances	7.6	7.2
Moisture	48.5	40.0

The average output of different products from one whale by proper utilization of the raw material (in tons) is as follows:

	Finback Whale	Sulphur-bottom Whale	Humpback Whale	Sperm Whale
Oil				
edible	10.5	16.5	6.0	—
industrial	—	—	—	6.0
spermacetic*	—	—	—	3.0
gelatin from meat and heart	0.7	1.1	0.4	1.2
preserves from meat and heart (weight of each can 510g)	21,270	33,725	7,050	—
dry food nitrogen**	1.08	1.70	0.36	0.29
bone meal	2.6	4.7	1.4	1.0
meal from the liver	0.14	0.19	0.10	0.10
campolon	0.027	0.037	0.020	0.020
Vit. A (in millions of international units)	500	2,300	176	1,850

* The output of spermaceti from one sperm whale was 0.35 tons.
** By utilization of meat and heart for dry protein preparation.

In addition, valuable drugs and commercial preparations may be obtained from the endocrine glands and brains.

For full and efficient utilization of all kinds of raw whale material, including the preparation of various foods and commercial and medical products, the whaler should be equipped with modern technical equipment suitable for the preparation of oil, bone meal, and semi-manufactured campolon. The coastal factories should be able to prepare protein, gelatin, and drugs.

The meat, liver, and endocrine glands, intended for preparation in the coastal factories, should be brought to the factories in their fresh or refrigerated states.

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RESEARCH ON ESTABLISHING OPTIMUM CONDITIONS FOR THE PROCESSING OF SUBCUTANEOUS WHALE BLUBBER IN THE VACUUM APPARATUS CHAIN OF THE "SLAVA"*

(Issledovaniya po ustanovleniyu optimal'nogo rezhima pererabotki pokrovnogo sala kitov na linii vakuum-apparatov kitoboinoi bazy "Slava")

K.A. Mrochkov, A.I. Gusev and F. Kolotvin

From the subcutaneous layer of blubber of whalebone whales (Mystacoceti) oil and blubber meal are processed in the vacuum apparatus chain of the "Slava" whaling base. The technological course of blubber processing consists of the following operations: 1) mincing of the blubber into hash, in a mincing machine, a blubber grinder, and a spinner consecutively; 2) heating of the hash in a preheater; 3) rendering the blubber in the hash by means of a vacuum boiler; 4) separation of the oil from the cracklings in an oil separator; 5) sedimentation of the oil in a separating tank; 6) separation of the oil.

The cracklings are conveyed from the oil separator into a "Zeer"** press for extracting the blubber remains. After mincing and chilling, the pressed cracklings constitute the finished meal.

The vacuum apparatus chain, compared to other types of blubber-rendering apparatus, is considerably more complex and has to be studied from various angles to achieve efficient operation.

In the course of several whaling trips by the whaling base "Slava" (1949/50 and 1952/54), studies of the vacuum apparatus chain were carried out along the following lines for the purpose of establishing optimum conditions for the processing of subcutaneous blubber of whalebone whales:

a) Study of the vacuum boiler operation.
b) Study of the operation of the "Zeer"(strainer) press.
c) Research into better methods of processing the pressed oil produced in the course of pressing the cracklings.
d) The production balance of the processing of subcutaneous blubber in the vacuum apparatus chain was studied.

The operating conditions for rendering blubber in the vacuum boilers, which is the basic operation of blubber processing, were studied under routine working conditions, the best experimental results being recorded.

At present the rendering of blubber in the vaccum apparatus chain is being carried out under optimum conditions at the "Slava" whaling base.

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* Studies were carried out with the full cooperation of the maintenance personnel of the vacuum apparatus chain.

**[Russian term for a strainer press. Translator's Note].

Rendering Blubber in a Vacuum Boiler

The essence of processing blubber in a vacuum boiler lies in the elimination of moisture, and the simultaneous rendering of the blubber performed below the deep vacuum - 700 - 750 mm Hg at the relatively low temperature of 50 - 60°.

The vacuum boiler (Figure 1) consists of a horizontally placed cylinder, the lower half of which is enveloped by a steam jacket. A steam dome of 0.4m^3 volume, connected to a condenser, is situated in the upper half of the boiler. Located on the inside of the boiler are 16 tubular steam discs 2 meters in diameter, rotating on a common axis. The range of the steam expansion of each disc is 4 cm. The rapid evaporation of moisture from the blubber occurs as a result of its contact with the heated surface of the boiler (steam jacket) and with the steam discs. The rotating discs obviate the risk of overheating the blubber by the steam jacket. The steam produced is subsequently withdrawn from the vacuum boiler, condensed, and thereafter utilized to supply motive power to other machines.

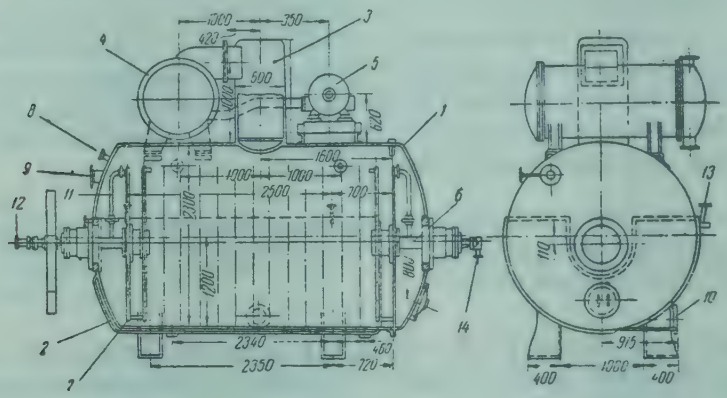


Figure 1. Sketch of vacuum boiler for blubber rendering
1 – horizontal stationary boiler; 2 – steam jacket; 3 – steam dome; 4 – condenser; 5 – vacuum pump; 6 – hollow shaft of the boiler; 7 – hollow discs; 8 – connecting pipe for water supply; 9 – sleeve for the loading of minced blubber; 10 – sleeve for extraction of boiled mass; 11 – connecting pipe for supplying steam to the discs; 12 – connecting pipe for steam supply to the shaft; 13 – socket for steam supply to steam jacket; 14 – sleeve for the condensate.

The blubber-rendering operation is controlled by: a vacuum gauge fitted to the vacuum boiler; manometers for measuring the steam pressure in the steam jacket and in the rotating discs, and also for measuring the air pressure inside the apparatus; thermometers to record the temperature of the steam in the boiler. The condensate reservoirs are equipped with vacuum gauges.

Blubber-rendering is the basic operation in the process of obtaining oil by means of the vacuum chain apparatus. The efficiency with which the blubber rendering process is performed, is the vital factor determining the output of oil, the quality fo the meal (moisture and oil content) and the rate of productivity.

In order to create the optimum conditions for the blubber-rendering process and to reach the maximum production rate of the vacuum boiler, studies were

carried out to determine the interrelation of the duration of the blubber-rendering process, the extent of the preliminary heating of the blubber, the amount of blubber loaded into the vacuum boiler, and the intensity of the steam supply to the boiler. Studies were also initiated to determine what changes occur in the chemical composition of the blubber during the heating operation, prospects being explored to find objective means of establishing the nature of the end product of the rendering down process.

Observations indicate that the mincing of the blubber (hash) prior to loading it into the boiler considerably affects the blubber-rendering process.

Increasing the temperature of the heated blubber from 20° to 40° greatly accelerates the rate of its suction into the boiler (approximately twofold), while the duration of the rendering process - even at a diminished rate of steam supply - is reduced by several times. Accordingly, the duration of the entire operational cycle (including the loading and unloading of the boiler) is considerably reduced, thus bringing about a significant increase in the output of the boiler. For example, when the boiler was loaded with a quantity of 5.35 tons, i.e., about 36% of its total capacity, the duration of the operational cycle was reduced from 1 hour 33 minutes to 1 hours 20 minutes, while the output of the boiler increased from 82.8 to 96.5 tons per day.

Heating of the blubber at a higher temperature (45 - 46°) did not produce any positive results. Furthermore, an intense boiling of the mass during its suction into the boiler might have damaged the vacuum pumps. The duration of blubber rendering would, in this case, have been considerably lengthened, deviating from its normal course and resulting in a deterioration in the quality of the oil and the blubber meal. Observations have established that constant heating of the blubber in the reservoir is not expedient.

Table I

Number of experiment	Loading of blubber into boiler in tons	Duration of boiling cycle in hours and minutes	Output of boiler in tons per day
Vacuum boiler No 1 with an approximate capacity of 16 m^3			
1	7.14	2—48	61.2
2	6.00	2—00	72.0
3	5.35	1—33	82.8
4	4.76	1—22	83.6
4,*a*	4.50	1—20	81.0
Vacuum boiler No 2 with an approximate capacity of 12 m^3			
5	5.35	2—29	51.7
6	4.76	2—04	55.3
7	4.16	1—30	63.1
8	3.57	1—13	70.4
8.*a*	3.40	1—10	70.0

The minced blubber should be slightly heated with mixing (10 - 15 minutes before loading); the steam pressure in the preheater must not exceed 0.5 atm.

In carrying out a study of the relationship between production efficiency and the capacity of the vacuum boiler, data was obtained as shown in Table I and Figure 2.

Any increase of the boiler's load results in a greater evaporation of moisture which makes it difficult to maintain a constant steam level and a high vacuum level in the boiler; the resulting steam pressure variations and the lowering of the vacuum level produce a nonuniform moisture evaporation from the blubber which, in turn, lengthens the duration of the blubber-rendering process, reduces the productivity, and causes a deterioration in the quality of the product.

From the data presented in Table I it may be observed that increasing the boiler's load up to 45% of its total capacity, made the process take twice the normal time, and reduced the productivity by more than 25%.

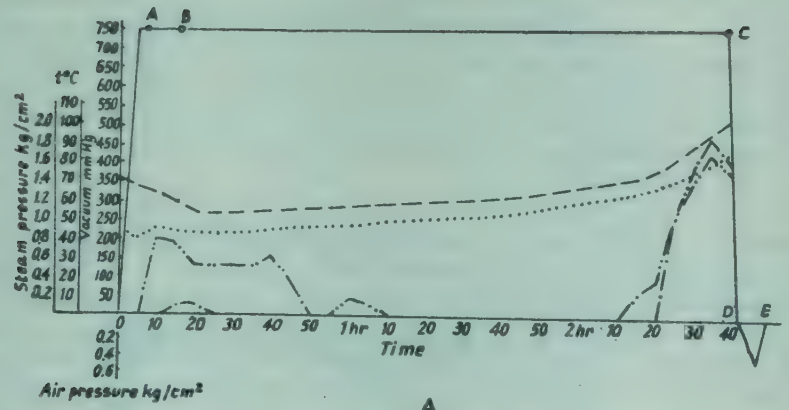
Accordingly, our observations indicate that the optimum load for a boiler is up to 30 - 35% of its total capacity (for boiler No 1, 5 - 5.5 tons, and for boiler No 2, 3.5 - 4.0 tons) which will enable the maintenance of adequate control of the blubber-processing conditions, thereby ensuring maximum efficiency of the whole system.

Table II and Figure 3 indicate the influence of the intensity of the steam suplpied to the rotating discs and the boiler jacket, on the duration of blubber processing and the boiler output when the load is constant(in the experiment when 5.35 tons were loaded into boiler No 1).

Table II

Number of experiment	Method of cooking				Duration of the cooking cycle in hours and minutes	Production capacity of boiler in tons per day
	Initial period		Final period			
	Steam pressure in kg/cm^2	Temperature of the mass in °C	Steam pressure in kg/cm^2	Temperature of the mass in °C		
9	0.2—0.3	56—44	1.0—1.5	64—74	1—48	71.3
3	0.2—0.5	53 - 43	1.4—1.7	72—85	1—33	82.8
10	0.6—0.7	57—48	1.8—2.0	85—87	1—25	90.6
11	1.0—1.1	71—56	1.5—1.8	82—87	1—15	102.7
12	1.0—2.0	73—64	1.7—2.0	85—93	1—04	120.3

Satisfactory results were obtained in those cases where the steam pressure in the boiler jacket and the discs at the beginning of the process constituted 0.6 - 0.7 kg/cm^2 (Experiment 10), and 1.0 — 1.1 kg cm^2 (Experiment 11), and which increased to 2 kg/cm^2 towards the end of the process. At reduced steam pressure (Experiments 9 and 3) the duration of the process was lengthened, and the productivity of the boiler decreased. An excessive steam supply at the beginning of the process would lead to a turbulent boiling of the mass in the boiler which, overflowing into the condenser, would result in decreasing the boiler's efficiency, thus causing a breakdown of the vacuum pumps. An excessive supply of steam to the boiler jacket, leading to overheating and turbulent boiling of the mass in the boiler, would constitute a grave danger.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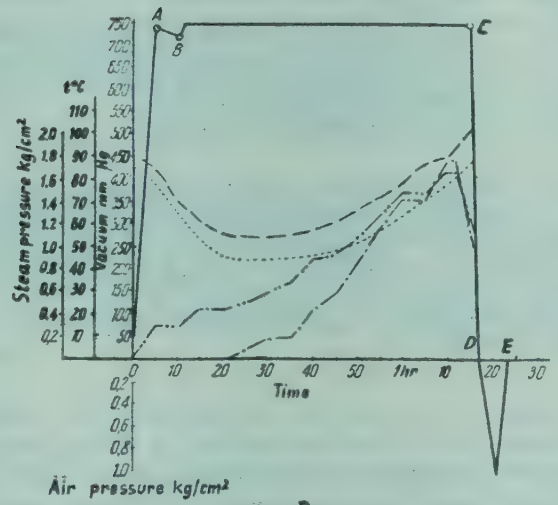
t°C
Steam pressure Kg/cm²
Vacuum mm Hg
Time
Air pressure kg/cm²

A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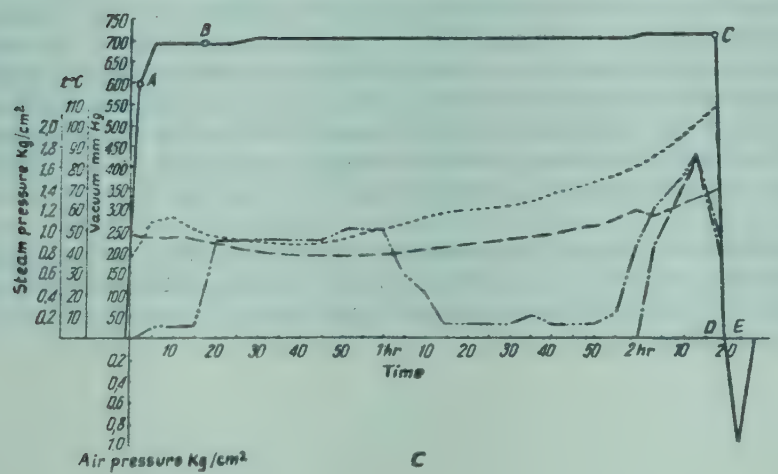
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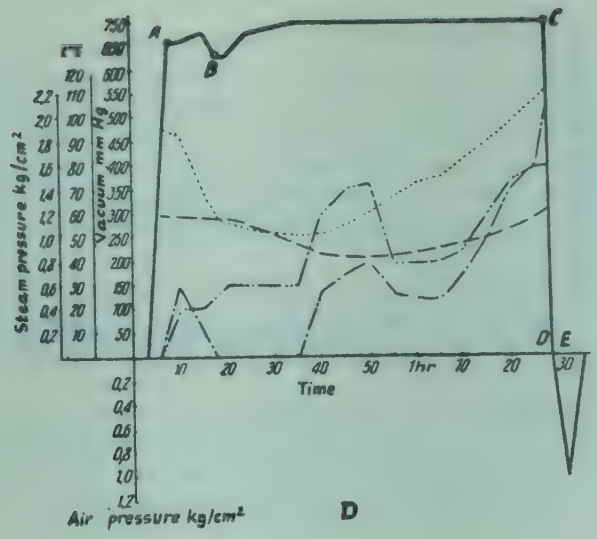

——————— Vacuum
– – – – – Temperature according to top thermometer
..... Temperature according to bottom thermometer
—·—·—·— Steam pressure in discs
—·—·—·— Steam pressure in jacket

Figure 2. Characteristics of the blubber-rendering method during various loadings of boiler
AB - loading; BC - boiling period; C - end of cooking; DE - emptying of boiler; A - experiment No 1; B - experiment No 4; C - experiment No 5; D - experiment No 7.

In order to prevent turbulent boiling of the mass in the event of an excessive steam supply, it is necessary to lower the vacuum in the boiler to 630 - 650 mm by admission of air (Experiment 12). A very thin stream of air entering through an air vent arrests the turbulent boiling, thus settling the mass and contributing to a more effective withdrawal of the water vapor from the boiler. In this way boiling proceeds gently and evenly without ejecting the mass into the condenser. An increased steam supply, with the boiler vacuum lowered by 50 - 75 mm Hg during an intense boiling of the mass, increases the boiler productivity by 20% (see Table II). However, regulation of the vacuum in the boiler, by means of the admission of a thin stream of air through an air vent, requires great care and must be cautiously and evenly performed, with constant observation of the condition of the mass in the boiler, by means of a viewing glass.

The condition of the equipment has an important effect on the duration of the blubber-rendering process; in the event of the condenser becoming clogged, it would be difficult to obtain a high vacuum in the boiler, thus retarding the withdrawal of the moisture.

The extent of mincing of the blubber also affects the duration of the blubber-rendering process. A more thoroughly minced blubber mass accelerates the blubber-rendering process, thus reducing the quantity of blubber remaining in the cracklings.

In all cases boiling of the mass in the boiler takes place at a certain point during the blubber-heating process, even with a relatively low steam pressure. This phenomenon is explained by the build-up of the pressure of the vapor formed within the cells of the blubber, causing them to burst. The boiling of the mass in the boiler is, in turn, accompanied by an increase of the quantity of the condensate formed.

Observations indicate that the final stage of the blubber-rendering process can be determined by the temperature of the boiling mass in the boiler, and the extent of condensate formation. In the course of blubber processing the temperature of the boiling mass varies with different species of whale, and also in relation to the oil and moisture content of the blubber. However, under all conditions, the blubber-rendering process is considered to have reached its final stage when the temperature of the mass in the boiler is 30° above its boiling temperature.

In the processing of fin-whale blubber the mass boils at 53 - 54°, and the process is completed at a temperature of 60 - 67°. Adding 30° to the temperature of the mass, it is found that the heating process of the blubber will reach its final stage when the temperature of the mass rises to 90 - 97°. In the processing of hunchback whale blubber, the temperature of the mass at the final stage of the process should be 7 - 8° higher, i.e., approximately 97 - 105°. With an optimum boiler load (established as being 35% of its total capacity) the amount of condensate deposited in tanks in the final stage of heating and after the boiling of the mass has come to an end, usually constitutes not more than 200 - 250 l.

The rate of moisture evaporation from the blubber is of the utmost importance in the processing of blubber in vacuum boilers. Samples were taken from the boiler for the purpose of studying moisture evaporation under various conditions of blubber processing, and for determining the influence of these conditions on the quality of the extracted blubber with particular reference to its acidity during the entire heating process.

Samples of blubber and cracklings were taken by means of a special selecting instrument installed on the boiler on the level of the lower thermometer. The intervals between the individual samplings varied from 5 - 15 to 30 minutes, depending on the rate of temperature increase of the mass in the boiler.

Variations in the moisture content of the crackling mass, observed under various experimental conditions, are indicated on Figure 4. Excessive moisture evaporation was observed during the initial period of the blubber processing when the temperature of the mass increased to 55°, and the vacuum in the boiler reached 700 mm Hg. During this stage more than 50% of the moisture contained in the blubber evaporated. With a further temperature increase of the mass from 55° to 70° approximately 35% of the moisture contained in the raw material evaporated and in the final stage of the heating process at a temperature above 70°, a further 10% of the moisture evaporated. Increasing the steam pressure in the discs and in the boiler jacket, as well as increasing the vacuum in the boiler, hastens the evaporation process, thus reducing the duration of heating of the blubber.

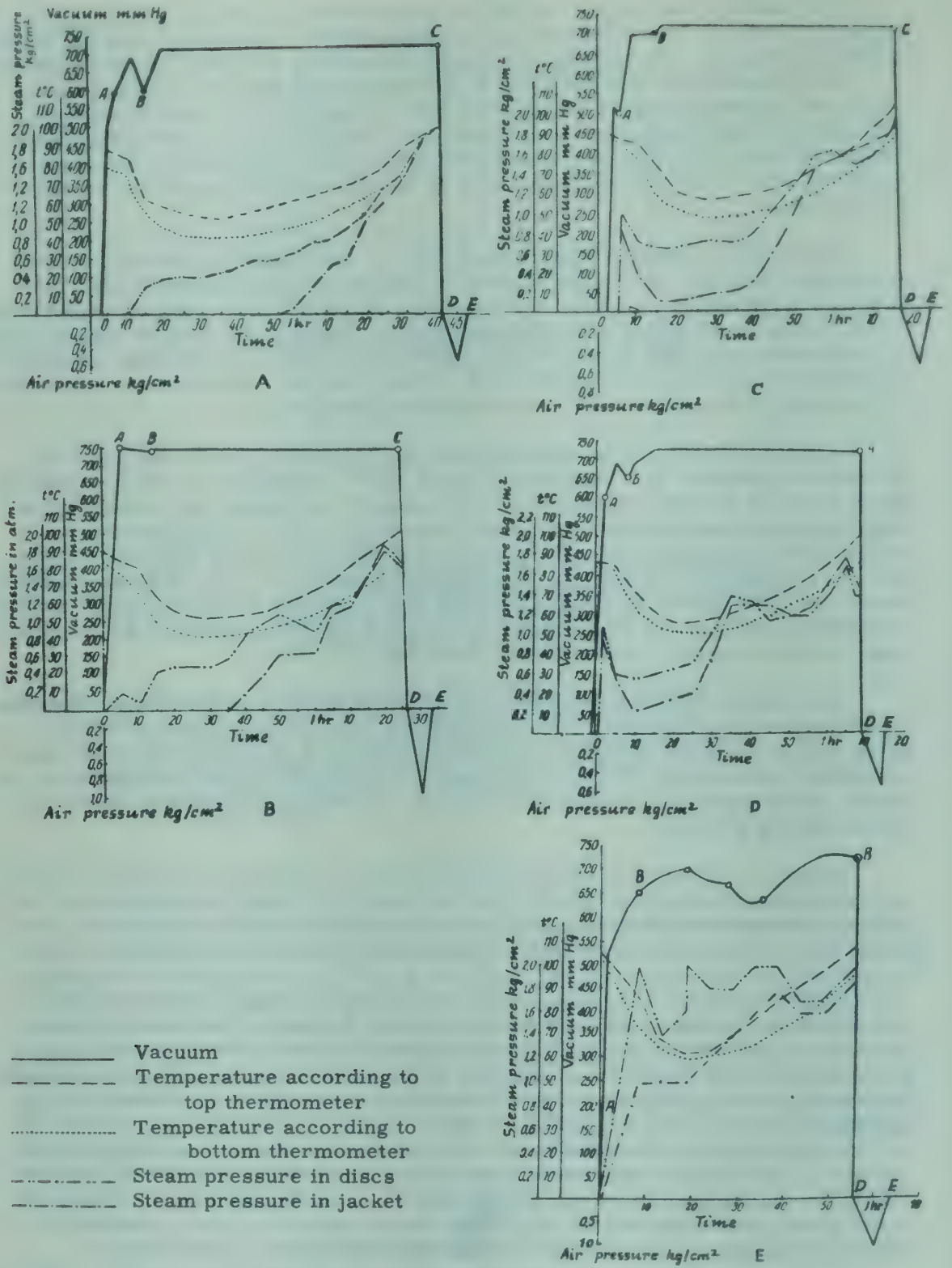

Figure 3. Characteristics of the blubber-rendering method (5.35 tons) during various intensities of steam supply to the jacket and the discs of boiler No 1

AB – loading of boiler; BC - duration of cooking; C - end of cooking; DE - unloading of boiler; a - experiment No 9; b - experiment No 3; c - experiment No 10, d - experiment No 11; e - experiment No 12.

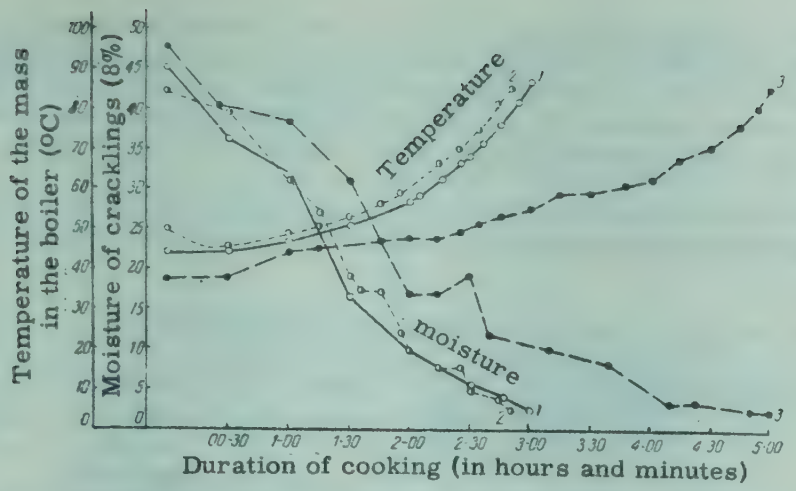

Figure 4. Changes in moisture content of whale blubber during the process of blubber-rendering in a vacuum boiler (according to data obtained from 3 experiments)

Experiment 1: Fin whale blubber. Steam pressure in the discs 0.2-0.3 kg/cm^2. No steam was directed into the jacket. Experiment 2: Blue sulphur-bottom whale blubber; steam pressure in discs 0.5-1.0 kg/cm^2; in jacket - 0.1 - 0.5 kg/cm^2; vacuum 700-720 mm Hg; Experiment 3: Fin whale blubber. Steam Pressure in discs 0.1 kg/cm^2 ; no steam was directed into jacket; vacuum 690-700 mm Hg.

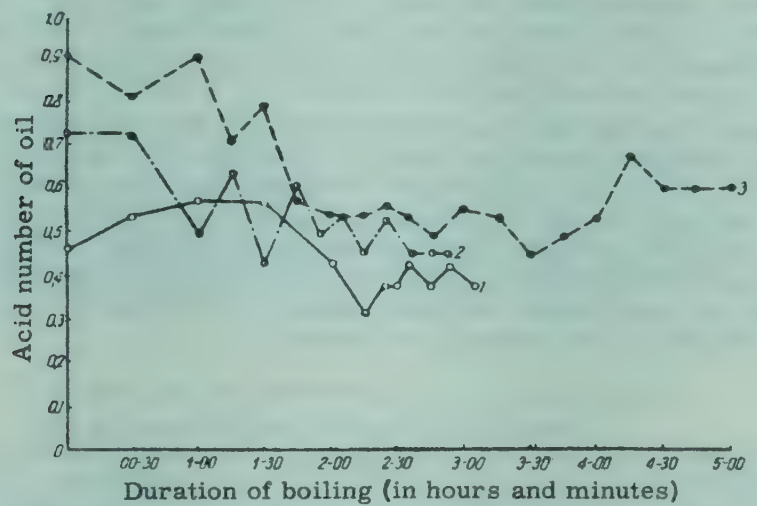

Figure 5. Changes in acid number of oil of subcutaneous blubber during rendering in vacuum boiler (according to data obtained from 3 experiments)

1- Fin whale blubber - steam pressure in discs 0.2-0.3 kg/cm^2 ; no steam directed into jacket; vacuum 690-710 mm Hg. 2 - Blue whale blubber - steam pressure in discs 0.5-1.0, and in jacket - 0.1 kg/cm^2; vacuum 700-720 mm Hg. 3 - Fin whale blubber - steam pressure in discs 0.1 kg/cm^2 ; no steam directed into jacket; vacuum 690-700 Hg.

In the course of heating the blubber its content usually decreases (Figure 5). This can be explained by the elimination of the free volatile acids from the blubber escaping together with the outgoing vapors into the condenser. It is noted that a

maximum decrease of the acid content of the blubber occurs during the intensive moisture elimination from the blubber as its temperature increases to 55–60°. An increase of the oil acid number was observed only during the course of a prolonged heating process due to a low steam pressure and an inadequate vacuum (curve 3). This phenomenon occurred during the final stage of the process.

Table 3 indicates the chemical characteristics of the blubber and of the oil and cracklings obtained from it; oil samples were taken from the oil-separator.

Table III

No of experiment	Blubber			Cracklings		Oil		
	moisture in %	oil in %	acid number	moisture in %	oil in %	Admixture of protein particles in %	moisture in %	acid number
3	25.9	66.15	0.89	1.66	43.60	traces	0.13	0.32
7	24.39	66.35	0,38	1.80	47,27	"	not determined	0.25
9	22.02	68.38	0.70	1.75	46,98	none	0,15	0.32
10	26.98	64.41	0.64	1.97	51.36	traces	0.16	0.32
11	31.23	57,18	0.51	4.09	45,47	"	not determined	0.25
12	24.25	64.56	0.32	1,99	46,33	0,09	0.09	0.26
13	19.06	72.82	0,52	0.96	50,69	0.04	0.17	0.26
14	46,19	45,22	0,64	3.30	56.20	not determined		
15	24,47	69.18	0.57	1,42	50.92	0.11	0,07	0.25
16	17.33	74.15	0.51	3.76	47.54	0,11	0.08	0.25

As seen from the data contained in Table III, the cracklings obtained in the course of the blubber processing contain an average of 2% moisture and approximately 50% oil. A lower oil content in the blubber (Experiments 11 and 14) and intense heating of the blubber prior to its being loaded into the boiler (Experiment 16) produced cracklings with a higher moisture content (3.3-4.1%). As a result, the oil extracted was of a high quality, being almost devoid of moisture and proteinaceous admixtures; the acid number of the oil varied from 0.2 to 0.6, being on the average two times less than in the original raw blubber.

Process of Filtering the Oil from the Oil Separator

Following the final stage of the blubber-rendering process the cracklings, together with the oil, are conveyed by means of compressed air into an oil separator where they settle within 5-10 minutes. The oil separator (Figure 6) consists of a metal vessel with a conical base having a capacity of 10 m^3. The lower part of the inner partitions and the bottom of the oil separator are constructed of plates whose cross section is trapezoidal in form. These plates are placed next to each other in such a manner as to leave longitudinal apertures between each other. For separation of the oil deposited from the cracklings, the oil separator is specially equipped with a bent drainage nozzle which permits the oil to be drained at a level lower than the oil outlet pipe. The oil is drained with the aid of a centrifugal pump. A certain quantity of the oil flows down through the plate apertures into the lower section of the oil separator, being subsequently drained by the same centrifugal pump into a discharge socket built in the bottom of the oil separator.

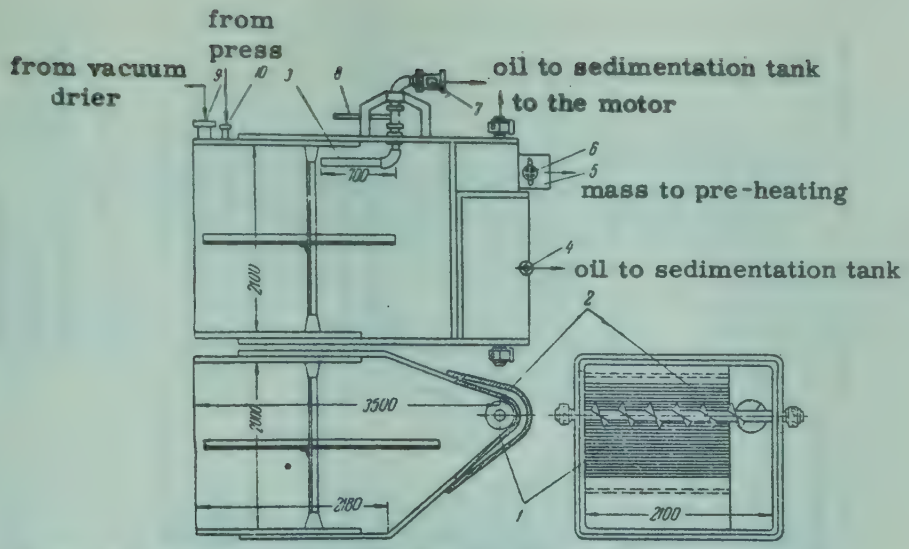

Figure 6. Diagram of oil separator for the separation of oil from cracklings

1 - screw conveyor; 2 - plates; 3 - bent nozzle; 4 - pipe for pumping out the oil; 5 - throttle pipe for removal of mass; 6 - cock; 7 - viewing glass; 8 - handle; 9 - pipe for loading of mass; 10 - pipe for extracted oil from the press.

Practice has shown that the filtration of the oil by means of the following pumps - STsL 20-24 or RZ-30 and ENP-2 - is smoother and more efficient when the moisture in the oil constitutes 1.5-2.5%. Under such conditions the filtering of 2.5-3 tons of oil (the output of one blubber-rendering process) took only 20 to 30 minutes. The filtering operation was impaired in cases where the cracklings were "undercooked" - having an increased moisture content (up to 4%) - and where they were "over-cooked" - having a moisture content of 1-1.5%. The "undercooked" cracklings appeared to have a soft, viscous consistency and tended to block the bottom of the oil separator so that much of the oil was detained. The "over-cooked" cracklings were very brittle, having the tendency to twist into a tangled mass. In both cases oil filtering may take up to 1.5 hours.

Processing of the Cracklings in a Strainer Press

The cracklings remaining in the oil separator after filtration had an oil content of 43-56%, constituting 8-10% of the total oil content in the blubber. In order to extract the oil from the cracklings, they were pressed by means of a strainer press, the design of which is shown on Figure 7.

Cracklings of a temperature not lower than 80° are fed by a worm conveyor from the receiving chamber into the pressing chamber. The latter is a cylindrical strainer consisting of a mesh system built of steel plates, having in its center a conical, noncontinuous worm press. In their cross section the mesh plates constituting the cylindrical strainer have a tapered (trapezoidal) cross section and are so placed as to leave clearances of between 0.4 mm (on the side of the incoming load) and 0.20 mm (on the side of the outgoing press cake). The oil, which is from the cracklings, comes out through the clearances between the plates. This we call the expressed oil.

Data showing characteristics of the method of pressing the cracklings are given in Table IV.

Table IV

No of experiment	Quantity of blubber located into boiler in tons	Temperature of cracklings before pressing in °C	Temperature of mass after pressing in °C	Duration of pressing in two presses in min	Composition of cracklings before pressing in %		Composition of meal in %		Characteristics of pressed oil			Notes
					moisture	oil	moisture	oil	moisture in %	Admixture of protein particles in %	Acid number	
7	4.16	110	125	46	1.80	47.27	3.25	10.74	0.33	not determined	0.32	Normal cracklings
9	5.35	not determined		55	1.75	46.98	3.70	10.40	traces	1.60	0.51	" "
10	5.35	103	100	35	1.97	51.36	5.10	10.90	"	3.72	0.38	" "
11	5.35	97	104	57	4.09	45.47	5.78	9.21	not determined		0.51	Undercooked cracklings
12	5.35	not determined		-	1.99	46.33	2.66	9.39	0.22	3.92	0.39	Normal cracklings
13	5.60	" "			0.96	50.69	2.76	9.42	0.24	3.81	0.52	" "
15	4.76	102	101	50	1.42	50.92	3.20	13.40	0.11	3.05	0.51	Slightly overcooked cracklings
16	5.35	105	95	35	3.76	47.54	3.80	11.18	0.26	2.75	0.51	Slightly undercooked cracklings
17	4.76	not determined		40	3.68	44.22	4.65	11.23	not determined			" "
18	4.76	104	120	40	2.47	43.37	4.86	10.37	"	"		Normal cracklings
19	4.76	104	110	40	1.83	42.66	2.34	14.41	"	"		Overcooked cracklings
20	4.16	70	85	45	1.44	47.03	3.70	11.90	0.22	5.60	0.64	Slightly overcooked cracklings

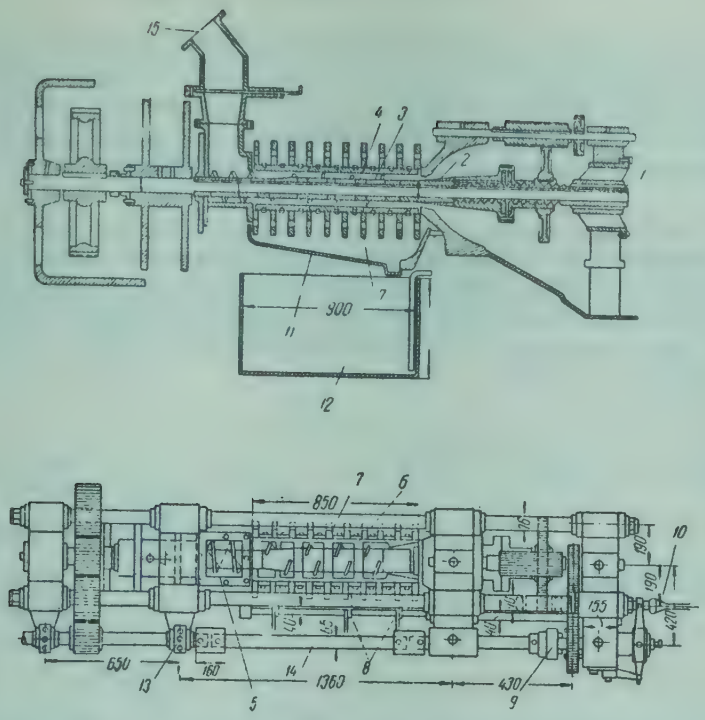

Figure 7. Diagram of strainer press for extracting cracklings

1 – shaft, 2 - split socket; 3 - worm sections; 4 - intermediate sleeve; 5 - feeding worm conveyor; 6 - press chamber; 7 - ribs of press chamber; 8 - tapered plates; 9 - coupling; 10 - handle; 11 - oil separator; 12 - oil tank; 13 - bearings; 14 - shaft; 15 - feed socket.

An important factor governing the extraction of oil from the cracklings during the pressing operation is the efficient performance of the heating process in the vacuum boiler. In efficiently carried out blubber processing (Experiments 7, 9, 10, 12, 13, 18). the quantity of oil extracted from the cracklings constituted 7-8% of the total weight of the initial raw material. In such a case the cake produced by the press has the form of small briquets (up to 10 cm long) which are easily ground into meal, and the press load does not exceed 45-50 atm.

When "overcooked" cracklings are pressed the oil output is somewhat greater, while the cake is very dry and friable. However, an increased quantity of admixture of protein particles (up to 4-6%) is present in the oil. In the pressing of "undercooked" cracklings the oil output is somewhat larger, but as a result of the increased moisture, the oil cake coagulates into a compact mass which twists around the press axis and emerges in clumps - the so-called "korzh"* which is difficult to grind even in a mill. The load of "undercooked" cracklings in a pressing operation constitutes 60-70 atm.

When the entire operation of the vacuum chain apparatus is carried out inefficiently, the blubber meal is obtained with a oil content of about 10% and a moisture content of 3-5%. The meal has a light-gray or light-brown color, and a slight smell of fried blubber. In structure the blubber meal can be fine-grained, friable, or coarse-grained with small baked clumps.

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* Ed. note: "Korzh" - Russian term for hard cake.

The Processing of the Extracted Oil

The extracted oil, in contrast to the oil separated from the cracklings in the oil separator, has a higher acid number and contains relatively more suspended protein particles which impart to it a darker color. Several methods of processing the oil have been tested: refining in the sludge separator, washing with a soda solution or sea water, or adding it to the blubber in the vacuum boiler.

Refining in the sludge separator appeared to be impracticable, since the mesh had to be constantly cleaned of the trapped protein residue, resulting in a decrease in output and requiring additional labor. Adding oil from beneath the press to the blubber in the vacuum boiler, did not produce satsifactory results either. Table V gives the characteristics of the oil obtained on cooking blubber with, and without, oil from under the press.

Table V

Cooking characteristics	No of experiment	Oil from oil separator			Extracted oil		
		Moisture in %	Admixture of protein particles in %	Acid number	Moisture in %	Admix. of protein particles in %	Acid number
Cooking of blubber without addition of extracted oil	15	0.11	0.7	0.25	0.11	3.05	0.51
	16	0.11	0.08	0.25	0.26	2.75	0.51
Extracted oil added to blubber before cooking began	12	0.09	0.09	0.26	0.22	3.92	0.39
	13	0.04	0.17	0.26	0.24	3.81	0.52
	21	0.11	0.10	0.25	0.22	3.08	0.38
Extracted oil added to vacuum boiler towards the end of cooking	20	0.22	0.31	0.38	0.22	5.60	0.64

As may be observed from the data in Table V, the oil obtained on heating blubber without adding extracted oil was superior in quality. The introduction of extracted oil into the vacuum boiler towards the end of cooking of the blubber resulted in an inferior quality both of the oil obtained from the oil separator, and of that obtained by straining the cracklings by pressure. In the case when the extracted oil was added to the blubber in the preheater prior to cooking, a compact mass formed at the bottom of the preheater, clogging the pipe system during the suction of the blubber into the boiler. Furthermore, a more turbulent boiling of the mass in the boiler was observed, which upset the operational conditions of the blubber heating. Addition of extracted oil to the blubber during the heating process is not desirable, since it decreases the productivity of the vacuum boiler as well as that of other machines in the vacuum chain.

Experiments of washing the extracted oil with a weak 0.01 % soda solution (Na_2CO_3) and with hot sea water produced excellent results. In the washing process, the protein admixtures of the oil swelled and settled to the bottom of the tub within a few minutes.

However, the method of washing with a soda solution is less convenient than using sea water since additional time and labor are expended in preparing the soda solution which also requires special storage.

As a result of a whole series of experiments of washing the oil with sea water in various ratios and temperatures, the following method was established as as the best. Sea water, in the ratio of 2 : 1, is added to a tub filled with oil, the water being first heated so that the resulting temperature of the oil-water mixture is not lower than 80°. The mixture is allowed to settle, the precipitated oil then being conveyed through a "Graks" separator.

In Table VI data are given specifying the fluctuations in the quality of the expressed oil in relation to the washing in hot sea water, and indicating the subsequent separation process which was observed during the processing of 8 tons of oil, the oil content of the drained water being about 0.7 %.

Table VI

Oil	Moisture in %	Protein admixture in %	Acid number
Initial extracted	0.69	Not determined	0.51
Oil after washing	6.70	1.22	0.51
Oil after separation	0.28	0.02	0.51

It may be assumed that equally good results would be produced by refining the oil by processing in a self-cleaning, constantly operating centrifuge (decantating apparatus).

Independent processing of the expressed oil results in a 15% increase in output in the vacuum apparatus chain.

Oil and Blubber Meal Output

In order to determine the output of oil and blubber meal, two experiments of fin-whale and blue-whale blubber were carried out. To complete the experiments quantitative and chemical analyses were carried out on the products derived at all stages of the technological process. The initial amount of fin-whale blubber constituted 9,110 kg, and that of blue-whale blubber, 9,360 kg. The output and chemical composition of the products are given in Table VII

On the basis of the data obtained on the output and composition of the various products, the ratio of the oil, moisture, and solid substances obtained in the course of blubber processing in the vacuum chain apparatus was established. Data contained in Table VIII show the calculations on the distribution of the individual components in the finished products, and their percentage relationship to their initial content in the blubber.

As may be seen from Tables VII and VIII, the output of finished, separated oil constitutes approximately 70% of the total weight of the processed blubber, of which 65% is obtained from the oil separator and 5% is extracted from the cracklings in the strainer press operation. The output of blubber meal varies from 7.5 to 11%, depending on the chemical composition of the blubber and its processing conditions. The output of finished oil constitutes up to 98% of the total oil content of the blubber, the loss being less than 1%, and the blubber meal containing only about 1-2%. The protein and the ash substances content pass, almost in their entirety, into the blubber meal.

Table VII

Name of product	Experiment with blubber of fin-whale					Experiment with blubber of blue-whale				
	Yield in % of initial weight of blubber	Acid number of oil	Chemical content in %			Yield in % of initial weight of blubber	Acid number of oil	Chemical content in %		
			Moisture	Oil	Solid substances			Moisture	Oil	Solid substances
Blubber	100	0.39	21.56	71.94	6.50	100	0.25	20.33	70.38	9.29
Oil, separated in oil separator	65.90	0.46	0.06	99.72	0.22	63.48	0.46	0.07	99.73	0.20
Cracklings before pressing	12.43	—	2.96	46.05	50.99	16.17	—	3.22	41.09	55.69
Cracklings after pressing (blubber meal)	7.51	—	6.07	10.97	82.96	11.11	—	4.71	13.69	81.60
Extracted oil	4.91	0.79	0.10	97.95	1.95	5.06	0.75	0.09	97.16	2.75
Mixture of oil (separated in separator and expressed) before separation	70.81	0.49	0.06	99.57	0.37	68.54	0.54	0.10	99.48	0.42
Oil after separation	70.49	0.43	0.29	99.52	0.19	68.49	0.50	0.30	99.49	0.21
Protein residue in separator*	0.02	—	52.20	39.44	8.36	— Not investigated				—
Water extracted on separation	—	—	—	0.3	—	—	—	—	0.25	—

* Part of protein particles remaining on the separator mesh during the straining of the extracted oil is not included in the calculation.

Table VIII

Name of Product	Distribution in % of initial content in raw material	
	Fin-whale blubber	Blue-whale blubber
	Oil	
Separated oil	97.99	97.30
Blubber meal	1.15	2.16
Protein residue after oil separation	0.01	unaccounted
Water extracted on separation	0.06	0.05
Losses	0.79	0.49
	Solid substances	
Blubber meal	95.96	97.58
Separated oil	2.66	1.55
Protein residue after oil separation	0,03	unaccounted
Losses	1.95	0.87
	Moisture	
Blubber meal	2.09	2.57
Condensate resulting from cooking of blubber in vacuum boiler	91.99	97.58
Losses	5.92	—

The losses of solid substances during blubber processing constitute 2.5-4.0 %, 1.5 to 2.1% of which is lost in the form of protein admixtures.

CONCLUSIONS

The research carried out on blubber processing in the vacuum chain apparatus allows us to draw the following basic conclusions:

1. The following method should be adopted for the process of rendering blubber in the vacuum boilers:

a) The minced blubber should be heated to a temperature of 30-35° before loading into the boiler.

b) The blubber mass to be loaded into the boiler should not exceed 30-35 % of the boiler's total capacity.

c) At the initial stage of blubber processing the steam pressure in the jacket and in the discs of the boiler should be maintained within the range of 0.6-1 kg/cm^2, while in the final stage of the process it should be 2 kg/cm^2. The possibility exists of increasing the steam pressure (up to 2 kg/cm^2) in the initial stage of the process for the purpose of accelerating the heating operation and so increasing output. However, the latter requires a most careful and accurate adjustment of the vacuum by admitting air through the air vent, in order to avoid turbulent boiling of the mass.

2). The termination of the blubber-cooking process can be ascertained by the temperature of the mass in the boiler at the end of boiling, and by the quantity of condensate formed after the boiling of the mass.

3. The extracted oil obtained during the process of pressing the cracklings, should be refined by the application of hot sea water (ratio 2 : 1), followed by separation in a sludge centrifuge. An alternative method of refining would be to strain the expressed oil through a decantating apparatus.

4. In the case of blubber heating in the vacuum boiler without the addition of any extracted oil, the decanted oil from the oil separator contains only slight quantities of moisture and admixtured protein particles, and therefore no cleansing of the separator is necessary. After a certain period, to allow the oil to settle,it can then be poured into tanks for storage.

5. In the processing of blubber, observing all the above-mentioned conditions, the final output of oil in relation to its content in the blubber reaches 98 %, constituting 65-70 % of the original weight of the blubber. The output of blubber meal constitutes from 7 to 12 % of the weight of the raw blubber, depending on its composition.

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CHANGES IN THE STRUCTURE OF THE SUBCUTANEOUS BLUBBER OF FINBACK WHALE DURING THERMAL EXTRACTION OF THE OIL

(Izmenenie struktury podkozhnogo sala kita finvala pri termicheskikh sposobakh izvlecheniya zhira).

A.N. Golovin

The subcutaneous blubber of sea mammals constitutes one of the sources of animal oil.

At present thermal methods (wet, dry, and vacuum) are employed for the extraction of oil from whale blubber. However, the partial incorporation and utilization of mechanical methods of oil extraction (pressing and impulse methods) do not necessarily obviate the need for further development of the technology of thermal methods of blubber processing, nor the need for study of the theoretical basis of oil extraction methods.

Diverse opinions exist at present regarding the best method of extracting oil contained in raw material of animal origin.

Professor V.V. Kolchev /4/ explains the mechanism of the procedure of oil extraction from oil-containing raw material originating from fish and sea mammals, basing his exposition on the fundamental principles of Professor A.M. Goldovskii's hydration theory.

Attempts have been made by Candidate of Technical Sciences S.G. Liberman and Engineer V.P. Petrovskii /7/ to apply the fundamentals of the hydration theory in order to elucidate the basic method of oil extraction from raw material of animal origin.

Professor A.A. Manerberger and Candidate of Technical Sciences E.F. Mirkin have proved the impossibility of applying the above-mentioned hydration theory for elucidating the process of oil extraction from terrestrial animals, since the nature and structure of animal and vegetable oils are different. According to their view, a total extraction of oil from animal raw material can be achieved only by destroying its structure. The destruction of the raw material occurs mainly in the course of the thermal processing, while a preliminary addition of water to the raw material only facilitates this process, since the fibers decreases during water absorption.

Whale blubber differs in structure and chemical composition from the fat of terrestrial animals and vegetable raw material. In view of this we carried out experiments for the purpose of a possible utilization of the fundamental principles of Professor Goldovskii's hydration theory for the elucidation of the mechanism of oil extraction from whale blubber.

Particular attention was paid to the study of changes in the blubber structure in the course of various processing procedures and conditions of oil extraction, assuming that this would enable us to establish more accurately the mechanism of oil extraction, and to determine the optimum conditions for blubber processing.

M. M. Sleptsov /11/, V. E. Sokolov /13/, Rachchu /20/, and others have studied the skin structure of the cetaceans. However, the studies carried out by these authors were limited to the structure of the skin in its original state only. The literature contains no information on the structural changes occurring in the whale blubber following thermal processing.

Histology of Raw Blubber

In the histological study the following problems were investigated:

1. To determine the state of the oil content of blubber, and the manner of its distribution;

2. To determine the form and proportion of the fatty compounds;

3. To determine the nature, state and disposition of the protein substances.

Blubber taken from the Antarctic finback whale, procured by AKF "Slava" during her whaling trip of 1954/55, was studied using the methods indicated in the Instruction Manuals of B. Romeis /10/, G. V. Yasvoin /15/, and others. Sections were prepared by a freezer-microtome.

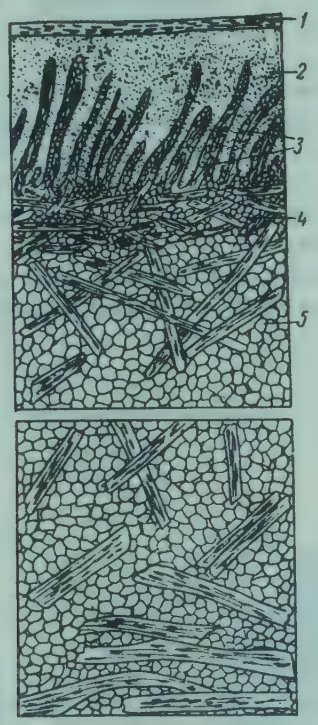


Figure 1. Structure of finwhale blubber

1 - outer layer of epidermis; 2 - stratum mucosum (prickle cell) layer of epidermis; 3 - papillary layer of dermis; 4 - sub-papillary layer of dermis; 5 - adipose subcutaneous cellular tissue.

Experiments have shown that the most favorable results have been achieved by the use of an alcohol solution of Sudan III, as a plasmatic staining agent.

The nuclei were stained by hematoxylin - according to Karrachi. In the course of staining the nuclei of adipose cells, bundles of collagen fibers were stained blue.

The staining of the sections, carried out in accordance with the Van Gisson method, enables us not only to establish the disposition and structure of the basic protein substances, but also to determine the nature of their viscosity.

Research has shown that finback whale blubber consists of three layers: the epidermis, dermis, and subcutaneous adipose tissues (Figure 1). The morphology of these layers is distinct. The epidermis consists of two distinct layers, the outer layer being 0.15 mm thick, and the inner sinewy layer being 1.85 - 2.85 mm thick. In the lower part of the epidermis, there are numerous nuclei into which penetrate dermal processes—dermal papillae. The depth of the nuclei, and consequently the height of the dermal papillae, varies (Figure 2).

The dermal part of the blubber consists of a thin layer (0.8 - 1.0 mm) of tightly intertwined bundles of collagen fibers with a mean diameter of 0.0325 mm, and papillae which, in their upward growth, enter the nuclei of the epidermis.

If the collagen fibrils of the dermal papillae are in a vertical or slightly inclined position, the bundles of collagen fibrils of the sub-papillae layer of the dermis will have an almost horizontal position.

Apart from the collagen fibril bundles in the nuclei of the epidermis, insignificant quantities of adipose cells of relatively small dimensions—a maximum diameter of 0.0785 mm—are also encountered.

The dimensions and disposition of the tissue elements vary in relation to the distance from the dermis; the diameter of the collagen fibril bundles increases, and their quantity decreases, acquiring a more vertical position. There is also a simultaneous dimensional and quantitative increase of the adipose cells.

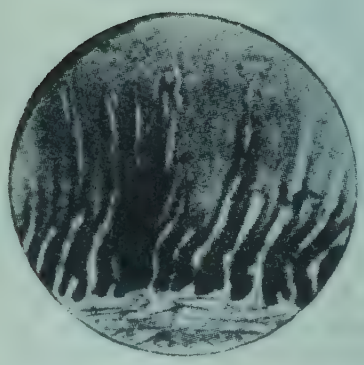


Figure 2. Arrangement of dermal papillae in the inner layer of the epidermis

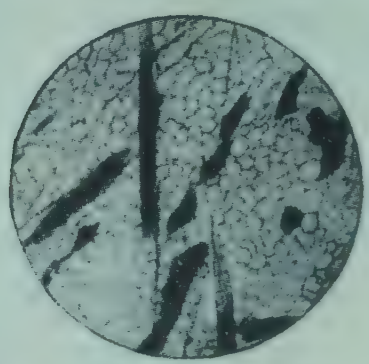


Figure 3. The form of collagen fiber bundles

Thus, the dermal part of the skin is transposed into the subcutaneous adipose tissues. The collagen fibril bundles of the subcutaneous adipose tissues vary according to the section, position, form and dimension.

The collagen fibril bundles of the upper and middle layers are at a considerable distance from each other, having a rectilinear appearance and being in an almost vertical position; the thickness of the bundles of the entire section is about 265 microns (Figure 3). The bundles consist of individual fibrils having a sinusoidal appearance. Nuclei are distinctly visible inside the bundle, having the form of small spindle-shaped rods situated along the bundle. Taking into account the presently available data on the biology of the collagen bundles, there is a basis for assuming that these nuclei belong to the "former" fibroblasts.

Closer to the subcutaneous muscles, i.e., in the lower layer, the collagen fibril bundles assume a more horizontal position, losing their rectilinearity and uniformity of thickness.

The quantity, dimension and form of the adipose cells also undergo changes, the main mass of these cells being concentrated in that part of the subcutaneous tissues where the collagen fibril bundles have a "rodlike" shape (in the upper and middle layers). The cells are polymorphous; however, the majority have a pentahedral or hexahedral form. Nuclei of rodlike shape with oval ends are discernible inside the cells close to the membrane. The remaining space is occupied by oil which has the appearance of a droplet.

In the lower layers of the subcutaneous adipose tissues the quantity of adipose cells is considerably less, in view of a considerable part of the space being occupied by greatly differentiated collagen bundles. The volume of the adipose cells is somewhat less, and their shape in the lower part of the subcutaenous adipose tissues is slightly oblong. The dimensions of the basic tissue elements, depending on their position in relation to the height of the subcutaneous layer are given in Table I.

Table I

Distance from lower margin of the epidermis in cm	Diameter of the bundles of collagen fibers in μ	Diameter of blubber cells in μ	
		largest	smallest
1	105.00	131.25	91.87
4	265.00	166.25	131.95
7	288.75	105.00	65.62

The histological studies carried out permit us to draw the following conclusions:

1. The main structural elements of finback whale blubber are the adipose cells and the collagen fibril bundles, forming the "skeleton" (framework) of the tissues.

2. The oil is enclosed in adipose cells, the main mass of which is located in the subcuteneous adipose tissues.

3. The dimensions, form, and disposition of the collagen fibril bundles vary in relation to their location in the different parts of the blubber.

In the upper and middle parts of the subcutaneous adipose tissue where the main mass of oil is concentrated, the collagen fibril bundles have an even, "rodlike" shape, and are located at different angles to each other.

In view of the fact that the basic protein in the blubber is composed of collagen (constituting most of the 80 % protein substance content), there is a basis for the assumption that collagen is the actual "laboring element" operating during the process of oil extraction. It is therefore desirable that greater effort should be made to increase our knowledge of its structural properties.

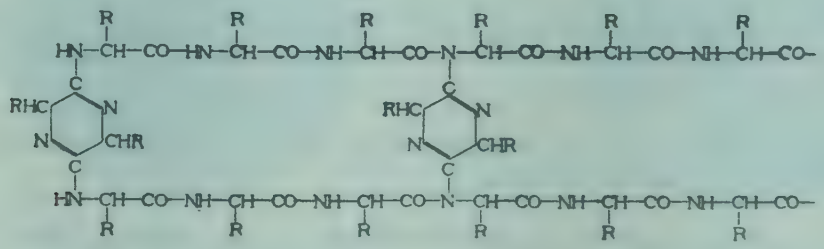
The Structure and Properties of Collagen

At present there is no unified opinion regarding the mechanism of the collagen fibril formation. Some authors /1/ consider that the indicated fibrils develop with the assistance of the embryonic cells of the mucous membrane fibroblasts. It is assumed that the fibrils emerge in the cells from the protoplasm, but thereafter become detached, thus losing their association with the cells. Others /2/ assume that the formation of the collagen in the organism is associated with the decomposition and oxidation of the primary proteins since much oxygen is present in its composition. There is also no comprehensive data on the structure of the collagen molecule. According to existing data the collagen molecule consists of a skeleton in the form of a polypeptide chain and side chains. The skeleton of the polypeptide chain is composed of interlinked peptide groupings (NH·CH·CO·), the length of which is 2.8 - 2.9 A^{o}.

Depending on the type, position and general state of the protein in the organism, the peptide chain may have either a contracted or an extended form; in its extended state it has a serrated shape. In relation to the alternation of the peptide groupings, the lateral chains are situated either above or below the surface of the primary peptide chain; the length of the chains varies; the thickness of each chain is accepted as 4.6 A^{o}.

Several theories exist in regard to the binding of the individual polypeptide chains in the protein molecule. Mikhailov /8/ indicates that the amino acids in the lateral chains are connected by the free carboxylic and amino-groups, according to the type of R_1NH_3 +/- $OOCR_2$ (electrovalent compounds). Thereby, the effect of the reaction between the charges is inversely proportional to the dielectric constant of the environment in which the protein exists. In water this bond is considerably weakened, and in its absence, possesses an energy of 100 kcal/mol.

The majority of authors consider that the fundamental form of the bond between the polypeptide chains and the lateral chains is the hydrogen bond between NH and CO and possibly, between CH and CO groups, in accordance with the following diagram*:



This assumption is based, in particular, on the premise that out of the total number of atoms entering the collagen composition, 50 % are hydrogen.

According to Zelinskii and Gavrilov /3/ the polypeptide chains can be linked by alpha-amidine bonds, which are formed between diketopiperazine rings situated in the lateral chains and the peptide groups of the adjacent polypeptide chains.

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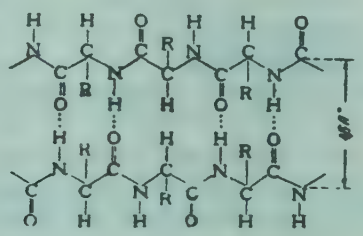
* /In the Russian text the two diagrams have apparently been erroneously interchanged - Trans. Note/.

In accordance with the diketopiperazine theory of the protein structure suggested by Zelinskii and Gavrilov, the protein molecules consist of individual interlinked microstructures built of cyclic groups, to which are attached peptide branches of short length (tri- and tetrapeptides).

Based on this theory, and on existing suppositions, a more realistic theory emerged regarding the structure of the protein macromolecule, which suggests the presence of a polypeptide-dihydro-pyrazine structure in which the peptide chains, consisting of tripeptide links, are connected with dihydropyrazine rings in accordance with the following diagram:



The works of Russian and foreign scientists—Chernov /14/ Levashev /6/ and Ninohe /19/ have established (Table II) that the majority of the amino acids contained in the collagen belong to the monoaminomonocarboxylic acids, a considerable number of which are glycine molecules. Proline and hydroxyproline have also been found in considerable quantities. The presence of aspartic acid and glutamic acid among the monoaminomonocarboxylic acids should be noted. The diaminocarboxylic acids are represented by arginine and lysine.

The amino acid sequence in the molecule chains of collagen is unknown. The majority of authors believe in the existence of a regular alternation of amino acids in the main chains of the collagen, suggesting various diagrams for the molecular chain.

The evaluations carried out by Astbery /16/ using the data of Bergman /17/ indicate that the sequence of alternation of the amino acids in gelatin is expressed by the following numbers: glycine 3, proline 6, hydroxyproline 9, alanine 9, arginine 18, leucine 18 and lysine 24. Astbury has suggested the following diagram of alternation of amino acids in the collagen molecule:

....P-G-R-P-G-R-P-G-R-...

where: P = proline or hydroxyproline;
G = glycine;
R = any of the other residues.

Table II

Nitrogen forms	Content in % of total collagen nitrogen	
	In sperm whale (according to data of Levashova /6/).	in blue whale (according to data of Ninche /19/)
Ammonia nitrogen	5.26	3.64 - 4.43
Humin nitrogen	0.42	0.68 - 1.16
Total diamino-carboxylic acid	25.65	20.9 - 22.2
Monoamino-monocarboxylic acid nitrogen	51.31	72.76 - 73.50
Imino-carboxylic acid nitrogen	11.64	

Sokolov /13/ has introduced a series of additions to the diagram, as a result of which the following expression is obtained:

$$G-\overset{+}{y}-P-G-R-O-G-\bar{y}-P-G-A-O-\cdots$$

where: G = glycine;
A = alanine;
R = residue with a nonpolar group;
O = residue with oxy-groups and
y = residue with ionic group (+) - basic, or (-) acid.

According to Sokolov, the "molecule" concept is not applicable to collagen, the chain of the main valences including the small peptide chains and dihydropyrazine interlinked with amidine compounds being accepted as the basic molecular unit.

X-ray research has shown that the "molecule" of collagen has a three-dimensional lattice and, consequently, three basic dimensions: 4.6 A°, 8.4 A°, and 11.3 A°.

A study of the collagen microstructure by means of an electron microscope permitted the determination of the dimensions of the primary structural element-protofibril. The diameter of the latter varies from 300 A° (for the light area) to 560 A° (for the dark area); the length of the light and the dark areas constitute 550 A° and 850 A° respectively.

The protofibrils have a transverse striation brought about by a regular alternation of light and dark areas and, being highly resilient, the light areas appear more elongated than the dark ones. The nature of these areas has so far not been established.

The works of Zaides and Pupko /2/ have not confirmed the Sokolov /13/ assumption to the effect that in the dark areas the polypeptide chains are folded.

Existing data permits representation of the collagen molecules in the following manner: the chemical elements form long peptide chains, having a width of 10 A° and a thickness of 15 A°; by their interlinking, the chains form protofibrils, the aggregate of which creates the primary collagen fibril, whose diameter is 10μ; the primary fibrils create a complex fibril of 100-200μ forming bundles of interwoven tissue.

It has been established by extensive research that the collagen fibrils contract and bend when heated. However, although their structure is altered, their chemical composition remains unchanged. In addition to the shortening of the fibrils (by 60 %) during the "cooking" of the collagen, disorientation of the polypeptide chains and disappearance of the transverse striation of the protofibril are also observed. In the course of "cooking" collagen absorbs heat to the extent of 20 cal per 1 g, characteristic of the melting of crystalline organic substances. Mikhailov /8/ therefore considers the collagen "cooking" as a melting process of a crystalline substance.

Changes in the collagen during heating depend on its water content; when fully saturated, the collagen cooks at a temperature of 60 - 70°.

With a lower water content the cooking temperature of the collagen increases.

In the course of heating an air-dry collagen to a temperature of 130°, the firmness of the soaked samples decreases, and they thereby lose their ability to revert to their primary length, in addition to which their resistance to enzymes grows. However, no indications of a "cooking" process were observed. Kutyanin /5/ has observed that "cooking" of an absolutely dry collagen takes place at a temperature of 210 - 225°.

According to Mikhailov's /8/ data liberation of the heat takes place, in the course of soaking the collagen, and the volume of the system "collagen-plus-water" decreases as a result of the added bound water. Removal of the bound water from the collagen alters its roentgenogram. A distinct X-ray photograph of collagen can only be obtained when the latter has a moisture content of 13 - 15 %.

Conforming with Pasynskii's data /9/, 2/3 of the water of hydration are bound to the peptide groups of the basic chain of protein, while only 1/3 is bound to the polar groups of the lateral chains.

The works of Astbery /16/ and Compton /18/ have shown that not all the water of hydration is bound in the same manner with collagen. Zaides also arrived at the same conclusion while carrying out analagous research work in TsNIKP (The Central Scientific Institute of the Leather Industry).

Astbery classifies the collagen water of hydration into "firmly" bound and "loosely" bound.

Many of the properties of the protein depend on the content of bound water (for example - the capacity of "swelling", "cooking", etc.). By increasing or decreasing the bound water content of the protein, and in particular of the collagen, the latter's properties and structural modifications may be altered, this factor being of primary significance in the process of oil extraction.

Tests have been carried out to determine the bound water content of the fin-whale blubber. These tests were carried out by the method of pressing, the results of which are given in Table III.

Table III

Material investigated	In % of weight of dry material		
	total amount of water	free water	bound water
Subcutaneous fin-whale blubber not less than 8 cm thick	229.00	168.08	59.92
As above, but thickness less than 8 cm	203.00	151.54	51.46
	216.00	160.31	55.69

Changes in the Structure of Blubber During Thermal Processing

In order to determine the role of water in the process of oil extraction, fin-whale blubber was processed by wet, dry and vacuum methods at temperatures of 50°, 65°, 100° and 120°.

In the course of oil extraction by the wet method water was first added to the blubber in the quantity of 25 %, 50 %, and 100 % of the blubber's total weight.

In the vacuum process a determined quantity of water was, for the purpose of this experiment, first removed from the blubber at a temperature of 46.5° and a vacuum of 680 mm Hg, following which the mass was heated to the required temperature. In the course of the dry oil extraction process, the blubber was not submitted to any preliminary preparations.

For all processes of oil extraction the blubber was sliced into pieces of approximately 2.0 cm in all three dimensions. The thermal processing of the blubber commenced from the time at which the required temperature was attained, and continued for 60 minutes.

The oil output obtained by the above-mentioned methods of blubber processing is given in Table IV.

Following the thermal processing and for the purpose of histological research, small portions of blubber were cut from the middle layer, i.e., at a distance of 4 cm from the lower limit of the epidermis.

The making of these slices from the samples of blubber and their processing was carried out in the same manner as during the investigation of raw blubber.

In the course of examination of the blubber after thermal treatment, particular attention was directed to the state of the adipose cells and the collagen fibril bundles.

OIL EXTRACTION BY A WET PROCESS. Heating at a temperature of 50° of blubber conditioned by the addition of 25 %, 50 % and 100 % of water did not produce any significant structural changes. The collagen fibril bundles and the adipose cells remained unchanged. The fibrils and the nuclei in the collagen fibril bundles were clearly discernible; also distinctly visible were the nuclei

in the adipose cells. Slight destruction of adipose cells and a concentration of free oil were observed only in the upper layers of the blubber (Figure 4). In the microphotographs the collagen fibril bundles are designated by the letter K, and the oil by the letter Ж.

In the process of heating to a temperature of 65° substantial changes took place in the structure of the blubber, a large number of destroyed adipose cells were absent, and it may be assumed that they became part of the composition of the emulsion. Within the inner layers of the blubber portions, a significant number of adipose cells remained in their whole state, although there were considerable changes in their form.

Table IV

Temperature in C°	Yield of unseparated oil in % of its content in the blubber in different processing methods						
	Wet method			Dry method	Vacuum method		
	amount of water added in % of weight of blubber				amount of water removed in % of its content in blubber		
	25	50	100		25	50	75
50	28.5	22.8	18.3	36.5	69.3	74.5	65.7
65	48.6	43.4	37.7	59.6	70.5	80.7	73.7
100	61.4	56.5	51.0	72.9	80.0	87.7	76.2
120	68.6	62.5	54.5	82.2	87.7	91.2	88.0

The majority of the collagen fibril bundles situated within the inner layers of the blubber portions retained their form; however, in a number of bundles the structure changed as a result of glutin formation. This explains the destruction of areas of fat-containing tissues, which was confined to the regions where collagen fibril bundles were interlinked with adipose cells.

It should be noted that at a temperature of 65°, with a 100% water addition to the blubber, the structural changes appeared to be less marked than with a 50%, or a 25% water addition (Figure 5).

The changes in the blubber at a temperature of 100 ° (Figure 6) appeared to be particularly marked with an additon of 25% of water. The form and the volume of the majority of the adipose cells situated in the upper layers and inside the blubber portions had changed. The formation of an emulsion was observed, and a significant amount of free oil accumulated in the upper layers of the portions.

The rectilinearity of the collagen fibril bundles and of the individual fibrils of the bundles were disrupted. In many places the connection between the changed structural elements was disturbed, which in turn explains the disruption of the oil-containing tissues.

With an addition of 50% and 100% water to the blubber the adipose cells located in the inner layers of the blubber remained undisturbed. (Figure 6).

Treatment of the blubber at a temperature of 120° produced noticeable changes in its structural elements. The adipose cells were entirely destroyed whatever the proportion of water added to the blubber. The collagen fibril bundles "cooked", thereby losing to a considerable extent their faculty for the formation of glutin (Figure 7).

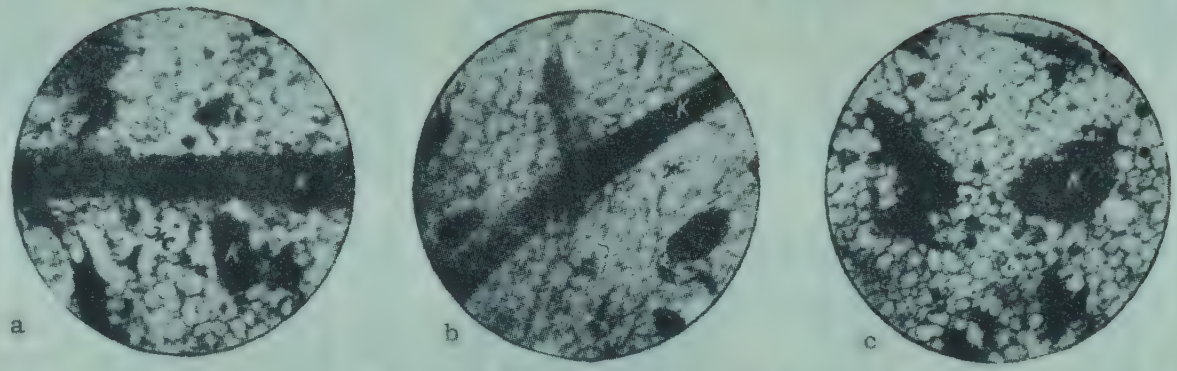


Figure 4. Structure of blubber after processing by the wet method at a temperature of 50°
Water added to blubber: a - 25 %; b - 50 %; c - 100 %.

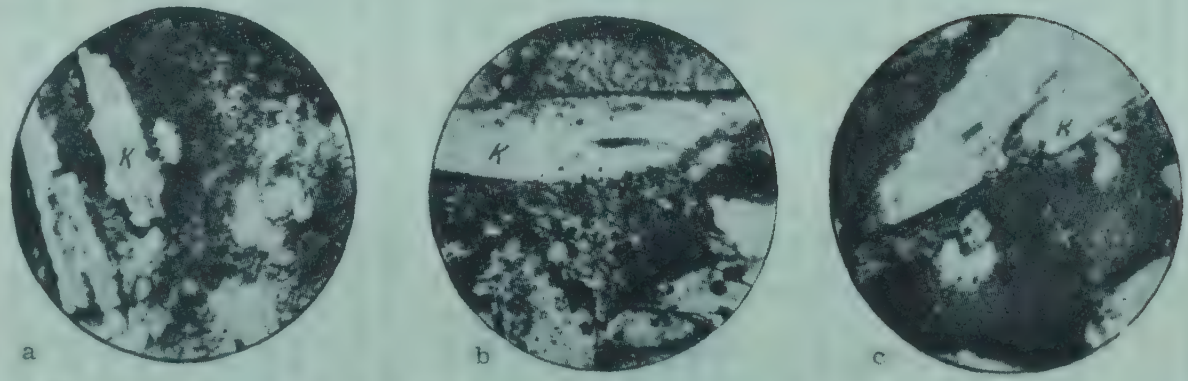


Figure 5. Structure of blubber after processing by the wet method at a temperature of 65°
Water added to blubber: a - 25 %; b - 50 %; c - 100 %.

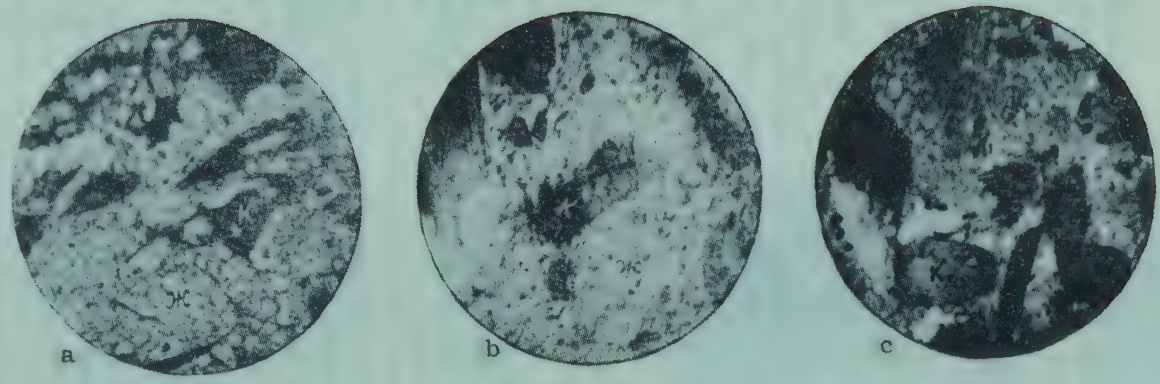


Figure 6. Structure of blubber after processing by the wet method at a temperature of 100°
Water added to blubber: a - 25 %; b - 50 %; c - 100 %.

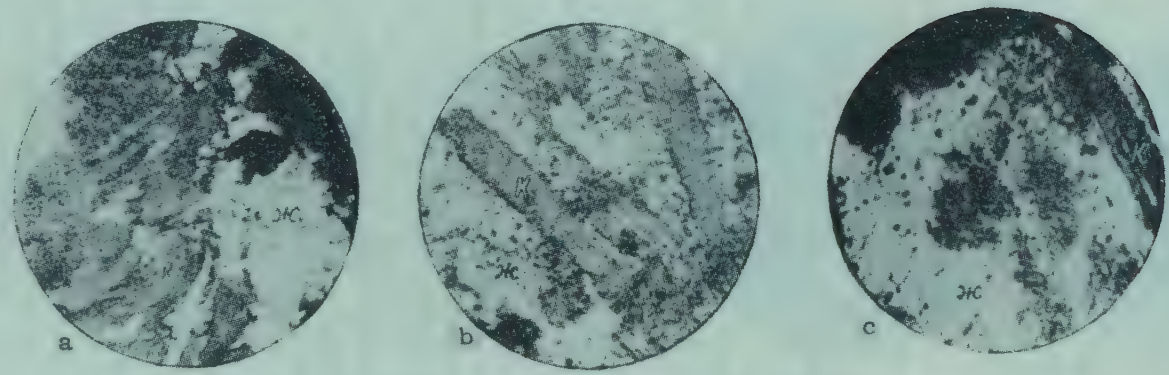


Figure 7. Structure of blubber after processing by the wet method at a temperature of 120°
Water added to blubber: a - 25 %; b - 50 %; c - 100 %.

OIL EXTRACTION BY THE DRY PROCESS. Changes in the structural elements of the blubber at a temperature of 50° were considerable. The basic mass of the adipose cells, in particular those located within the inner layers of a piece of blubber remained undisturbed. A partial destruction of the adipose cells was observed in the upper layer of the piece, and also in the region of linkage with the adjacent substance. A significant quantity of free fat was found on the surface of the blubber.

The collagen fibril bundles appeared to remain intact. The nuclei and the fibrils were distinctly discernible therein, which indicated that the phenomenon of "cooking" did not take place. (Figure 8a).

The heating of the blubber at a temperature of 65° was accompanied by a substantial change in its structure. A significant number of the membranes of the adipose cells were destroyed, while substantial changes occurred in the form of the adipose cells which remained whole. Large accumulations of free fat were concentrated in the upper layers of the pieces of blubber.

The form and the structure of the collagen fibril bundles changed and, as a result of the "cooking" of the collagen, the bundles became markedly shorter.

When the surface occupied by the adipose cells in the raw blubber exceeded the surface occupied by the collagen fibril bundles, the surfaces of the above-mentioned structural elements in the "cracklings", obtained after heating the blubber at a temperature of 65°, were almost identical. Such equalization of the surfaces occurred as a result of a significant extraction of the oil, induced by the change in structure of the contiguous substance, this being connected with the change in the form of the remaining adipose cells. (Figure 8b).

The nature of the structural changes in blubber effected by the temperature of 100° and by the temperature of 65° was the same, the changes however, being more marked with the higher temperature. This pertains to both the collagen fibril bundles, and the adipose cells. The disruption of the connection among the structural elements, induced by their alteration, markedly decreased the mechanical strength of the oil-containing tissues. As a result of this, it is impossible to obtain whole, thin, intact (10 - 15 microns) section.

"Cooked" collagen was the main constituent by volume of the pieces, and the destroyed membranes of the adipose cells, together with the residual oil were present in the space between the "cooked" collagen fibril bundles. Changes occurred in the form of the adipose cells which remained intact, (Figure 8c).

At a temperature of 120° very marked changes were observed in the blubber structure. The adipose cells were destroyed, and the collagen fibril bundles were "cooked". Small quantities of oil enclosures, consisting of destroyed adipose cell membranes combined with free oil, were present in the space between the collagen fibril bundles. Numerous ruptures of the adipose tissue were observed both in the area where the changed adipose cells were accumulated, and in their points of contact with the collagen fibril bundles, thus indicating the complete loss of mechanical stability by the structural elements of the blubber (Figure 8d).

OIL EXTRACTION BY THE VACUUM PROCESS. Pieces of blubber, from which 25 % of the water content was removed following a heating process at a temperature of 50° for one hour, displayed minor changes in form and volume. The surfaces became coarse as a result of considerable dehydration of the collagen fibril bundles located in the upper layers.

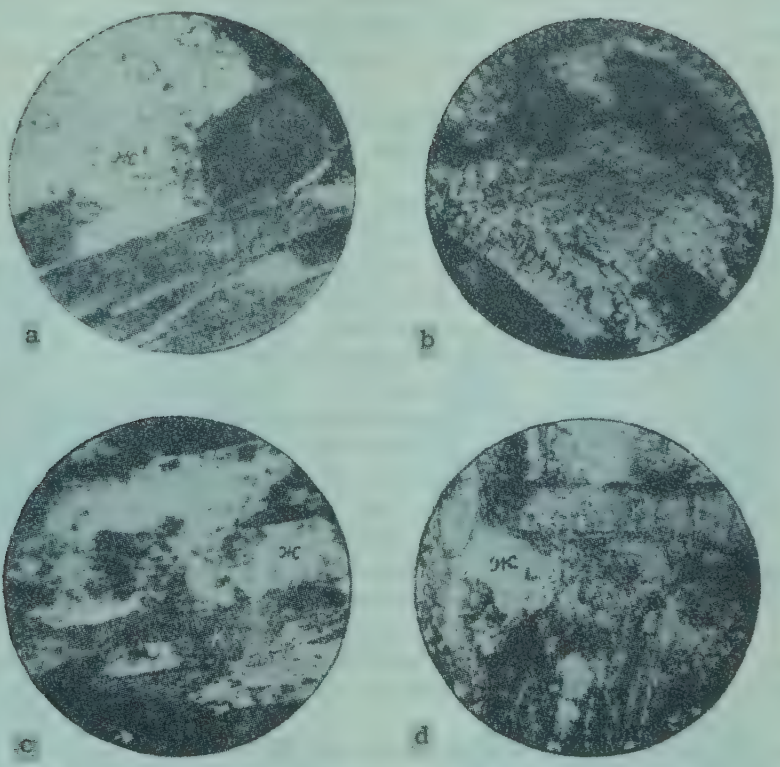


Figure 8. Structure of blubber after processing by the dry method
a - at 50°; b - at 65°; c – at 100°; d – at 120°.

Curvature and thickening of the collagen fibril bundles located in the inner layers of the blubber occurred, thus indicating that the phenomenon of "cooking" had taken place. Simultaneously, although the collagen fibril bundles located in the upper layers did not become "cooked", they developed a distinct corrugation occasionally breaking into individual fibrils, or groups of fibrils, having a serrated form. In addition, the upper bundles did not stain in a satisfactory manner.

The majority of the adipose cells, especially those located in the upper layers, were destroyed, and accumulation of free oil was observed, mainly located near the partly dehydrated collagen fibril bundles (Figure 9a).

Removal of 50 % of the water content caused structural changes analagous to those observed after removal of 25 % of the water content. However, in this case, the collagen fibril bundles located in the deeper layers became dehydrated as a result of which the "oil ring" encircling the pieces of blubber became considerably wider. The adipose cells located in the area of the dehydrated, weakly stained "corrugated" collagen fibril bundles were completely destroyed.

The majority of the collagen fibril bundles were found in a "cooked" state, indicating that a more intense cooking had taken place than in the case when 25 % of the water content was removed.

Very few of the adipose cells retained their original form. (Figure 9b).

More pronounced structural changes occurred in the case of a 75 % dehydration. In this case, as a result of the water loss, the diameter of all collagen fibril bundles showed a marked decrease (from 265 to 52.5 - 87.5 microns). The majority of the adipose cells were destroyed as a result of the indicated changes, as was almost the entire structure of the blubber tissue.

A considerable quantity of free oil was located (Figure 9c) in the neighborhood of the dehydrated changed forms of the collagen fibril bundles.

Removal of 25 % and 50 % of the water content of blubber, followed by a heating process for oil extraction at a temperature of 65°, produced structural changes analogous to those which occurred at a heating temperature of 50°. It should be noted, however, that at a temperature of 65°, the "cooking" of the collagen fibril bundles was more marked, this phenomenon being also observed among the collagen fibril bundles located in the upper layers, the former being dehydrated as a result of their location. A more intense "cooking" of the collagen fibril bundles induces a more pronounced reduction of their length and an increase of their diameter which, in turn, leads to a marked contraction of the space between the bundles. A small quantity of oil together with the membranes of the destroyed adipose cells occupy the remaining space between the bundles, the main oil mass having been extracted (Figures 10a and 10b). The phenomenon of "cooking" of the collagen fibril bundles is not observed when 75 % of the water content is removed. However, their diameter is considerably decreased and they appear to be curved. The corrugation of the collagen fibril bundles appears to be deeper. The adipose cells are destroyed entirely. The modified collagen fibril bundles are encircled by free oil (Figure 10c).

The preliminary removal of 25 % and 50 % of the water does not preserve any of the collagen fibril bundles, including those located in the upper layers of the piece of blubber, the same effect also applying to partly dehydrated blubber at a temperature of 100°. Under these conditions, adipose cells which fully retained their original form and dimension were not observed. Numerous ruptures occur within the oil-containing tissues. It should be noted that, on removal of 50 % of the water the "cooked" collagen fibril bundles constitute the basic mass of blubber residue ("cracklings").

Any quantities of oil remaining in the residual scraps of blubber are insignificant (Figures 11a and 11b).

When 75 % of the water is removed and the blubber subsequently heated at a temperature of 100°, "cooking" of the collagen fibril bundles does not occur. After the removal of this amount of water, the changes occurring in the structural elements of the blubber are analogous to those observed in the course of heating blubber at a temperature of 50° and 65° (Figure 11c).

The nature and the extent of the structural changes of the blubber brought about at a temperature of 120° following a water removal of 25 %, 50 % and 75 %, were the same as those occurring in blubber processing at a temperature of 100 ° following removal of the indicated quantities of water (Figures 12a, 12b and 12c).

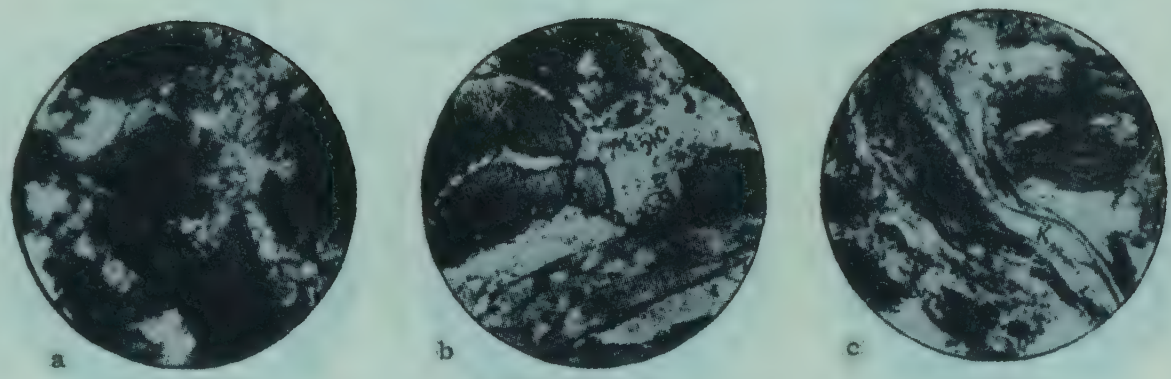


Figure 9. Structure of blubber after processing by the vacuum method at a temperature of 50°
Quantity of water removed from blubber: a - 25 %; b - 50 %; c - 75 %.

Figure 10. Structure of blubber after processing by the vacuum method at a temperature of 65°
Quantity of water removed from blubber: a - 25 %, b - 50 %; c - 75 %.

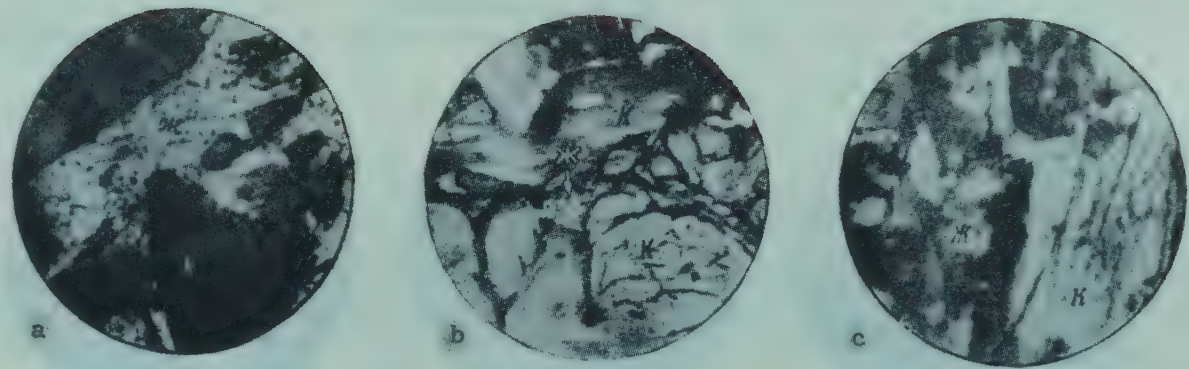


Figure 11. Structure of blubber after processing by the vacuum method at a temperature of 100°
Quantity of water removed from blubber: a - 25 %; b - 50 %; c - 75 %.

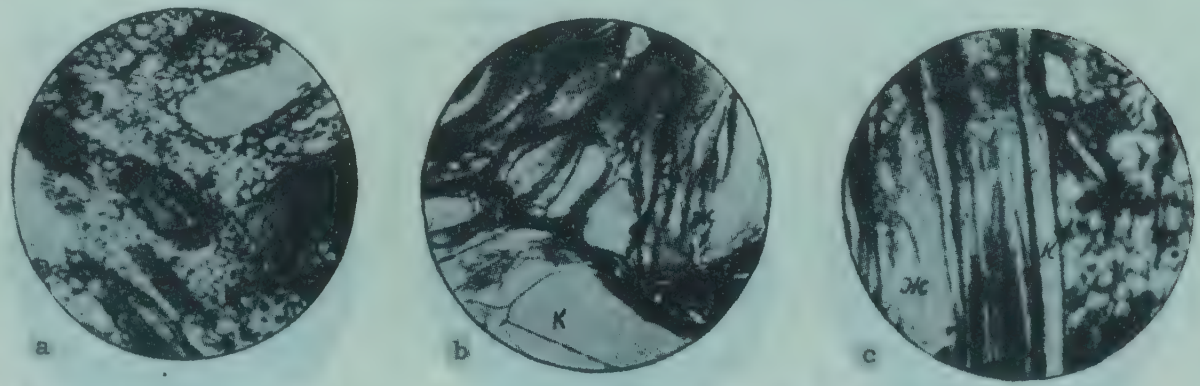


Figure 12. Structure of blubber after processing by the vacuum method at a temperature of 120°
Quantity of water removed from blubber: a - 25 %, b - 50 %; c - 75 %.

CONCLUSIONS

1. Increasing the amount of water added in the course of thermal processing of blubber does not increase the oil output, but actually decreases it. This provides a basis for the assumption that the fundamental conditions of the hydration theory of Professor A. M. Goldovskii are not applicable for the elucidation of the mechanism of oil extraction from whale blubber.

2. The oil output depends essentially on the nature and the degree of the changes occurring in the structural elements of the blubber during thermal processing.

3. Basic changes take place in the blubber structure at a temperature of 60° and above, as indicated by the observation of the destruction of adipose cells and the changes occurring in the collagen fibril bundle structure.

The nature of the changes occurring in the collagen fibril bundles depends on their water content, and also on the temperature and the pressure under which the oil extraction process takes place.

4. Upon addition of water to blubber in the course of thermal processing, splitting of the collagen fibril bundles occurs, followed by the formation of glutin.

5. In the course of blubber processing without adding water and, furthermore with a 70% removal of the water content, "cooking" of the collagen fibril bundles takes place ,this being characterized by their decrease in length (60%) and increase in thickness.

6. More intense "cooking" of the collagen fibril bundles takes place on removal of 50% of the water from the blubber, and subsequent thermal processing at a temperature of 100°. Under these conditions of blubber processing maximum oil output is observed.

7. Preliminary removal of more than 70% of water from blubber not only leads to a complete destruction of the adipose cells but also impedes the process of "cooking" of the collagen fibril bundles, thereby decreasing the oil output of the blubber.

Calculations show that when more than 70% of the water is removed from blubber, or more correctly, from the collagen, a partial removal of water of hydration takes place.

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PRODUCTION OF SEMIPREPARED CAMPOLON FROM THE FRESH LIVER OF ANTARCTIC WHALES

(Prigotovlenie polufabrikata iz svezhei pecheni antarkticheskikh kitov)

A. N. Kulikov, K. A. Mrochkov and S. N. Surzhin

At present, the fresh liver of cattle, which is an extremely valuable food product, is being used for the production of the medical compound campolon, used for the treatment of pernicious anaemia.

Studies carried out by R. R. Perepletchik and E. I. Novikova /4/ have shown that the liver of sea mammals, particularly of whales, can be utilized for the preparation of campolon, in place of cattle liver. Of utmost interest in this respect is the liver of whales procured in Antarctic waters by the whaling fleet "Slava".

Campolon is a liver juice extracted from a heated liver mass and subjected to a special process for concentration, separation of the protein substances, and preserving.

Under the conditions prevailing on the whaling base "Slava" it would be difficult to carry out the complex operations entailed in the preparation of campolon from liver. However, it is possible to produce semifinished campolon in the form of a concentrated liver juice for subsequent final processing ashore.

With this in mind, experiments were carried out in the course of several expeditions of the "Slava" (1951 - 1955) for the following purposes:

1. To determine the quality of the whale liver in relation to the period of time elapsing between slaughtering and processing;

2. To prepare experimental samples of semiprepared campolon;

3. To determine the possibility of utilizing whale liver for the production of both campolon and vitamin A.

Influence of the Time Elapsing Between Slaughtering and Processing on the Quality of the Liver

Campolon is used medically for intramuscular infection, and must therefore be prepared from whale liver of the highest quality. Fresh liver is evaluated mainly by organoleptic examination based on such indicators as color, odor, consistency, presence of ruptures, etc. It should also be noted that any deterioration in the quality of liver is accompanied by the presence of hydrogen sulfide.

In order to obtain data on the quality characteristics of liver obtained in the course of whale processing, observations have been made on the extent of accumulation of hydrogen sulfide in the liver, in relation to the period of time elapsing between slaughtering and processing (Table I).

Table I

Quality of Liver	Time (in hours) between killing and cutting up of the whale					
	1 - 12		12- 18		18 - 27	
	No of tests	% of total no of tests	No of tests	% of total no of tests	No of tests	% of total no of tests
Fresh	13	72.2	10	62.5	2	11.8
Of doubtful freshness	2	11.1	1	6.2	3	17.7
Not fresh	1	5.6	2	12.5	2	11.8
Putrefied	2	11.1	3	18.8	10	58.7
	18	100.0	16	100.0	17	100.0

Observations have been made of the liver of the main species used in the whaling industry—finback whale—which constitutes up to 85% of the total whale catch in the Antarctic.

In order to determine the hydrogen sulfide contained in the liver, a standard method was applied.

In relation to the organoleptic evaluation of the presence of hydrogen sulfide the liver was categorized as follows:

1. Fresh-normal color of liver, red-brown, consistency firm, reaction to H_2S—negative (H_2S—);

2. Doubtful freshness—color slightly pale, reaction to H_2S—slightly positive (H_2S +);

3. Not fresh—color light grey, liver inflated due to accumulation of gases within the tissues; reaction to H_2S—positive (H_2S ++);

4. Putrefied—color, dingy grey, liver very inflated, gas bubbles emanating from cuts, reaction to H_2S—markedly positive (H_2S+++).

Research has shown that variations in the quality of the liver occur at any period of storage after slaughtering. This is actually due to the physiological condition of the animal at the time of its death, and to the extent of the damage caused by the grenade explosion (muscles, head, abdominal region). Generally, any damage to the internal organs of the whale causes a rapid deterioration of the liver. Table I shows that the extent of deterioration of the liver's quality is also influenced by prolongation of the period during which it remains in the body of the dead whale.

The above indicates that for quality evaluation of the raw liver for production of the semiprepared campolon, it is necessary to take into account the period from the slaughtering of the whale until its processing.

Table II indicates various periods of time between the slaughtering and the whale processing (finback), according to the data collected by the scientific group which accompanied the whaling fleet "Slava" on three whaling expeditions (1951 - 1954).

As seen from Table II, about 55 % of the entire finback catch was brought for processing within twelve hours from the time of capture, within 12 - 18 hours about 21 %; within 18 - 27 hours, approximately 16 %; and more than 27 hours after slaughtering, approximately 9 %.

Inasmuch as the finback whale constitutes the overwhelming majority of whales caught in the Antarctic, the indicated timetable of processing may be considered as generally applying to an entire whale catch.

Table II

Season of catch	Number of whales in % of their total number processed after different time lapses from the killing			
	from 1 to 12 hours	from 12 to 18 hours	from 18 to 27 hours	Over 27 hours
1951/52 (6th expedition)	51.98	23.63	16.94	7.45
1952/53 (7th expedition)	55.09	19.85	15.73	9.33
1953/54 (8th expedition)	57.89	19.84	14.84	7.44
Average	54.99	21.11	15.83	8.07

Applying these data, as well as the data on varying qualities of liver in relation to the actual time of the liver remaining in the body of the slaughtered whale (Table I), the respective quantity of liver of varying quality obtained on one whaling expedition can be calculated.

The results of such calculations are shown in Table III.

Table III

Quality of liver	yield from liver in %			
	1951/52	1952/53	1953/54	Average
Fresh	54.3	54.0	55.9	54.7
Of doubtful freshness	10.2	10.2	10.3	10.2
Not fresh	7.9	7.4	7.5	7.6
Putrefied	27.6	28.4	26.3	27.4

As may be seen, the output of liver of varying quality is sufficiently uniform, and absolutely fresh liver fit for campolon preparation can be obtained, from an average of 55 % of all whales caught (Table III).

Liver of doubtful quality (approximately 10%) containing traces of hydrogen sulfide, can be utilized in a preserved state for the production of vitamin A. Putrefied liver with a soft consistency and a marked hydrogen sulfide content (an average of 30 - 35 %) cannot be utilized for any medical purpose.

Taking into account that the number of whales caught by the "Slava" fleet on one trip is 2.750 /1/ and that the average weight of each whale liver is 0.55 ton /3/, it can be assumed that during one whaling expedition a quantity of 800 - 850 tons of whale liver can be utilized for campolon preparation .

Preparation of Semi-Prepared Campolon

The semiprepared campolon was at first obtained with experimental, and later with industrial equipment of the whaling base.

The process for the preparation of the product consisted of the following operations:

Fresh liver was cut into pieces of 2 - 3 kg by means of flange knives, eliminating the largest bile and blood ducts consisting of elastic connective tissue. The liver pieces were minced after having been thoroughly washed with water which had been allowed to drain off. Subsequently the minced liver mass, together with its juice, was placed into tin-plated tanks which were thereafter placed in hot water at a temperature of 80 - 85°. The liver mass was heated to a temperature of 70° with constant mixing. The heated mass was pressed through a linen fabric (belting) by means of a screw press. For extraction of the juice, bags containing the liver mass were placed in a press of a type described in Figure 1.

The extracted juice, having the apperance of a red-brown liquid, was concentrated at a temperature of 70° until the specific gravity of the concentrated residue reached a minimum of 1.1. In the experimental phase the juice was evaporated in a double-walled boiler placed in a steam (water) jacket, and equipped with a mechanical mixer. In the industrial phase the juice was evaporated in a vacuum apparatus (Figure 2), which considerably accelerated the process (by more than 20 times).

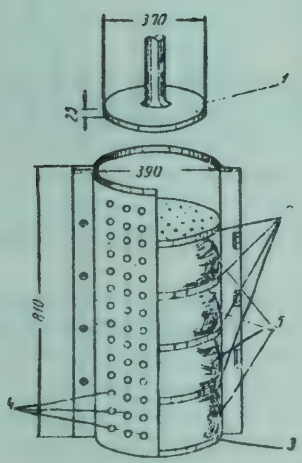

Figure 1. Strainer press for extracting juice from liver

1 - press disc; 2 - strainer discs with holes 15 mm in diameter; 3 - bottom; 4 - frame with holes 17 mm in diameter; 5 - bags with liver mass.

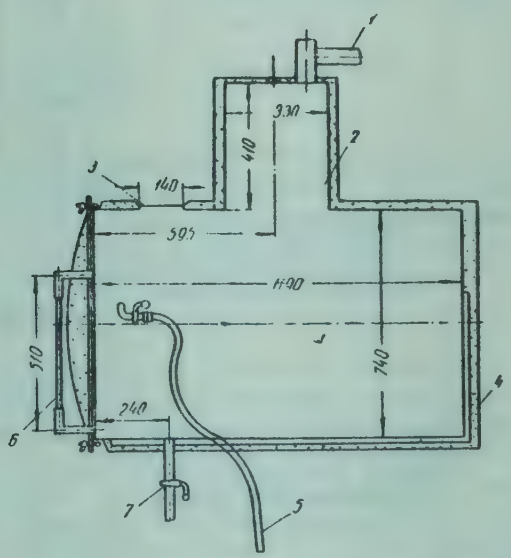

Figure 2. Vacuum boiler for steaming liver juice

1 - connecting pipe for sucking off steam to condenser; 2 - steam-collecting chamber; 3 - viewing glass; 4 - steam jacket; 5 - hose for suction of liver juice; 6 - juice level indicator; 7 - release tap for steamed juice.

The concentrated juice, having been filtered through a special fabric (belting) for separation of the coagulated protein substances, was poured into tin containers

of 8 l capacity, metal tanks and glass bottles of 15 l capacity; phenol, in the amount of 0.25 % by weight, was added to the liquid as a preserving agent. The tin containers were soldered, the glass bottles were tightly closed by a stopper and sealed with tar, and the tanks were covered in the usual manner without being hermetically sealed. The semiprepared campolon in the tin containers was twice pasteurized at a temperature of 70° for one hour, with a 24-hour inverval between pasteurizations, during which the product was maintained at room temperature (18 - 22°).

Following the pasteurization, the tin containers were cooled by sea water (overboard) at a temperature of 8 - 10°, while the bottled product was not pasteurized at all.

After preparation as described above, the semiprepared campolon was kept under refrigeration at a temperature of 0° for six months, prior to being despatched ashore.

The total period of time taken to prepare the semiprepared campolon (including the packing) from 1 ton of liver, using industrial equipment, was on the average 24 hours.

Table IV gives calculations of weight data collected at various stages of the process, specifying production output and the amount of waste.

Table IV

Test No	Conditions under which product is obtained	Yield in % of the initial weight of whole liver							
		Quantity of processed liver in kg	Liver cleaned and cut up	Minced liver	Minced liver mass after heating	Pressed liver residue (cake)	Expressed liver juice	Protein residue after filtering of steamed juice	Ready, semiprepared campolon
1	The product was prepared with experimental equipment (tests made in 1951/52)	201.0	92.8	88.9	84.9	38.8	38.9	0.9	12.3
2	"	179.6	93.1	89.2	86.7	40.8	41.9	0.9	9.5
3	The product was prepared with industrial equipment (test made in 1953/55)	432.0	-	-	-	50.46	49.5	-	9.4
4	"	462.0	-	-	-	42.21	57.8	-	12.1
5	"	388.5	-	-	-	43.60	56.4	-	10.6
6	"	536.8	-	90.1	-	46.55	39.7	-	16.8
	Average	-	92.9	89.4	85.8	43.7	47.4	0.9	11.8

The output of concentrated liver juice, being the semiprepared stage of the campolon preparation, varied from 38.9 to 57.8 %, considerably exceeding the previously indicated /4/ ratio of liver juice output from refrigerated whale liver—31.0 - 38.4 %. The lower juice output from refrigerated liver may be explained by the changes in structure and composition (moisture decrease) of the liver during its refrigeration and storage, and by the partial loss of juice in the course of thawing.

The semiprepared campolon constituted an average of 25 % of the weight of the juice expressed from the liver, i.e., approximately 12 % of the weight of the initial liver mass.

In the course of preparation of the semiprepared campolon the waste products are: residual liver mass following juice extraction (cake), protein precipitate separated in the process of filtering the concentrated juice, and the liver vascular tissue cut off in the course of processing. The quantity of "cake" constituted an average of 43 - 44 % of the total weight of the liver, the protein precipitate approximately 1 %, and the cut-offs approximately 7 %.

The semiprepared campolon prepared on the "Slava" whaling base was, after several months storage, processed ashore in a special plant where it was brought to its final stage. The output of the finished campolon constituted an average of 35 % of the weight of the semipreprared product, with a respective specific weight of 1.08 - 1.13.

The activity of the campolon made from the half finished product prepared on the whaling base was identical to that of the finished product prepared in the plant from refrigerated whale liver delivered ashore/4/.

The Possibility of Simultaneous Production of Semiprepared Campolon and Vitamin A

Essentially, the antianaemic properties of campolon are conditioned by presence therein of a complex of vitamins of the B group (folic acid and vitamins B_1, B_2 and B_{12}). These vitamins, being water-soluble, separate from the liver in the course of juice extraction. In addition to the vitamin B group, whale liver contains a considerable quantity of fat-soluble vitamin A /2/, which remains in the residue of the liver mass following the juice extraction process.

In order to resolve the question of the utilization of fresh whale liver for the simultaneous production of campolon and vitamin A, it was necessary to carry out a study of the changes occurring in the properties of the liver in the course of preparing the semi-prepared campolon. With this in view, a whole series of analyses was performed on the initial fresh liver material, on the extracted liver juice, and on the residual liver mass after juice extraction (cake), as well as on the semi-prepared campolon product in relation to their content of moisture, oil, solid nitrogen and mineral substances and vitamin A. The results of these analyses, carried out in the course of the experimental preparation of semiprepared campolon in 1951/52, are given in Tables V, VI and VII.

As may be observed (Table V) processed finback whale liver, according to its chemical composition, was homogeneous. The vitamin A content of 1 g of liver averaged 530 int. units.

The composition of the finback whale liver used for producing the semiprepared campolon under industrial conditions in 1953/54, was similar to that found in the liver used for experiments made in 1951/52, and contained an average of 74.40 % moisture, 3.93 % oil, and 21.47 % solid residue in the form of nitrogenous and mineral substances.

Table V

Test No	Kind and sex of whale	Length in m	Time elapsing between killing and cutting up (hours and minutes)	Duration of storage of liver before processing	Organoleptic evaluation of liver	Test by hydrogen sulfide	Moisture in %	Oil in %	Solid substances in %	Vitamin A in int. unit per gram
1	Finwhale (male)	19.5	3—00	1—00	Good quality, compact, of reddish-brown color	Negative	74,50	1,67	23,83	519
2	" "	18.9	7—30	00—15	" "	"	76.75	1.42	21.83	613
7	" "	17.2	6—00	2—40	" "	"	75.07	2.31	22.62	403
8	Finwhale (female)	20.3	6—30	1—50	" "	"	74.54	1.94	23.52	592
					Medium quality		74.65	1.84	22.95	532
10	Humpback whale (male)	13.1	14—30	1—00	Good quality, compact of brownish color	Negative	72.38	4.44	23.18	457

Table VI

Test No	Kind of whale from which the liver was taken	Juice expressed from liver					Semiprepared campolon				
		Moisture in %	Oil in %	Compacts elements in %	Vitamin A in int. units per gram	Specific weight at 20°	Moisture in %	Oil in %	Solid substances in %	Vitamin A in int. units per 1 gram	Specific weight at 20°
1	Fin whale	91.64	0.02	8.34	None	1.039	80.47	0.14	19.39	None	1.110
2	"	93,49	0.13	6.38	Traces	1.029	78.01	None	21.99	None	1.160
7	"	87.99	0.04	11.97	None	1.040	77.41	0.04	22.55	None	1.132
8	"	92.67	None	7.33	None	1.036	74.85	None	25.15	Traces	1.130
10	Humpback whale	92.75	0,57	6,68	Traces	1.028	73.92	0,02	26.06	None	1.120

Examination of the juice extracted from liver and of the semi-prepared campolon (Table VI) showed that they were almost entirely devoid of oil and did not contain vitamin A.

Conversely, the residue of liver cake remaining after juice extraction, contained a considerable quantity of vitamin A (Table VII).

Consequently, in the course of preparation of the semi-prepared campolon, the vitamin A is retained almost in its entirely in the residue, after juice extraction.

One gram of obtained "cake" contained an average of 4 % oil, and from 730 to 1420 int. units of vitamin A; the "cake" moisture constituted an average of 57 %.

A product with such a moisture content is not suitable for storage. Tests of the given product carried out during storage on deck at a temperature of 0 - 5°, and in closed premises at a temperature of 12 - 15° proved that the product deteriorated after a period of 5 - 10 days, as indicated by a marked darkening of the color, the presence of a sour odor and of mold. Experiments with the preservation of "cake" by salting in barrels with dry salt (up to 30 % of its weight) also gave no positive results.

In order to permit prolonged storage the best method appeared to be air-drying of the ground product, thus reducing the moisture content to a maximum of 10 %.

The prepared dry products (ground and granulated) kept well in nonhermetically sealed sacks and paper bags for more than 5 months at temperatures varying from 0° to 35°.

The dried cake (Table VII) is a protein and vitamin concentrate which could serve as valuable cattle fodder. It can also serve as raw material for the preparation of vitamin A.

Table VII

Test No	Kind of whale from which the liver was taken	Moist cake				Dried cake			
		Moisture in %	Oil in %	Solid substances in %	Vitamin A in int. units per gram	Moisture in %	Oil in %	Solid substances in %	Vitamin A in int. units per gram
1	Finwhale	57.41	3.83	38.76	890	Not investigated			
2	"	57.31	4.02	38.67	1420	"			
7	"	56.19	3.40	40.41	1042	"			
8	"	58.10	5.45	36.45	1254	7.38	8.34	84.28	3373
9	"	57.00	3.15	39.85	895	7.00	8.65	84.35	2706
10	Humpback	54.3	7.57	38.12	736	Not investigated			

CONCLUSIONS

Finished campolon can be produced from semiprepared campolon prepared under industrial conditions from fresh whale liver at the whaling base "Slava".

It has been established that an average of 55 % of the livers of the entire whale catch for the prodcction of the semi-prepared campolon are suitable. The total quantity of whale liver which can be used for the production of the semiprepared campolon constitutes an average of 800 - 850 tons in one whaling expedition.

The output of semiprepared campolon constitutes an average of approximately 26 % of the weight of the extracted liver juice, or 12 % of the total weight of the fresh liver.

In the course of preparing the half-finished capolon, the Vitamin A is retained in the liver residue (cake) which constitutes about 45 % of the total liver weight.

For the purpose of more practical exploitation of the residual whale liver after preparation of the semiprepared campolon, the "liver cake" should be dried and subsequently processed ashore for preparation of the Vitamin A concentrate; and also the protein substances, for use as cattle fodder.

In addition to the 55% of the absolutely fresh liver suitable for simultaneous production of campolon and Vitamin A, liver (in the salted state), in which insignificant changes have occurred can also be used to the extent of 10 % for the production of Vitamin A. Therefore, an average of 65 % of all whale liver obtained in the Antarctic fishing grounds is suitable for the preparation of medicinal products.

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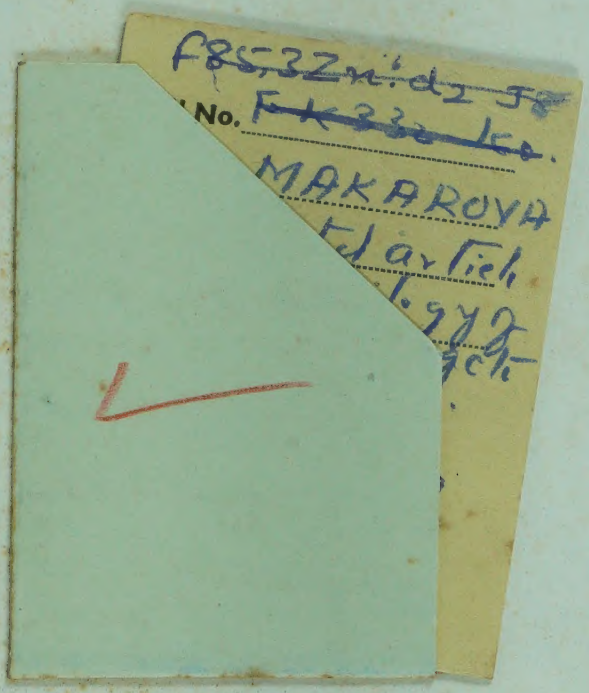
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